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Cost and Capability Evaluation of the Marine Corps Combined Arms Regiment (CAR)

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NAVAL POSTGRADUATE SCHOOL
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THESIS

Cost and Capability Evaluation of the
Marine Corps Combined Arms Regiment (CAR)

by

Robin G. Gentry

December, 1993

Thesis Advisor: Michael G. Sovereign

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One result of the break-up of the Soviet Union is that the DOD has been forced to reevaluate the roles of each of the Armed Forces based on the declining resource pool. From the Marine Corps' evaluation of itself came the Combined Arms Regiment (CAR) concept. The objective of this study was to develop an estimate of the Life Cycle Cost (LCC) of the two possible vehicles used with the CAR and the CAR's components. Standard cost factors are used to cost out the various organizations involved.

Two supporting analyses done in this study are: an evaluation of the Marine Corps' role in national security and how the CAR could be used to support that security role, and a comparison of the vehicle option operating characteristics which was done to enrich the dimensions under which the CAR could be evaluated. The results of this study are a tool which can help Marine Corps planners make more informed decisions in regards to the CAR concept. The final conclusion, based on the assumption that any CAR would act as a follow-on element of the MAGTF, was that although the CAR(LAV) was a workable option, the CAR using upgraded AAVs was the better, more cost effective option.

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Cost and Capability Evaluation of the Marine Corps Combined Arms Regiment (CAR)

by

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Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

One result of the break-up of the Soviet Union is that the DOD has been forced to reevaluate the roles of each of the Armed Services based on the declining resource pool. From the Marine Corps' evaluation of itself came the Combined Arms Regiment (CAR) concept. The objective of this study was to develop an estimate of the Life Cycle Cost (LCC) of the two possible vehicles used with the CAR and the CAR's components. Standard cost factors are used to cost out the various organizations involved.

Two supporting analyses done in this study are: an evaluation of the Marine Corps' role in national security and how the CAR could be used to support that security role, and a comparison of the vehicle option operating characteristics which was done to enrich the dimensions under which the CAR could be evaluated. The results of the study are a tool which can help Marine Corps planners make more informed decisions in regards to the CAR concept. The final conclusion, based on the assumption that any CAR would act as a follow-on element of the MAGTF, was that although the CAR(LAV) was a workable option, the CAR using upgraded AAVs was the better, more cost effective option.

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I. INTRODUCTION

A. BACKGROUND

As the United States continues the force drawdown of the 1990's, resources will be short in supply. This has forced the Department of Defense to completely reevaluate its programs and purpose. Each service has begun a complete analysis of its roles and missions to determine what the best force structure is to meet the new challenges of the future. For its part, the United States Marine Corps began a zero base review in August of 1991, directed by the Commandant and headed up by Lieutenant General Charles C. Krulak (then a Brigadier General). The Commandant charged a planning group under General Krulak to provide an executable plan that would attain the most effective and capable force for the Marine Corps at a size of 159,000 Marines (Thomas,1992, p.34). The review was to begin from scratch rather than simply evaluating alternatives to the current baseline structure. One outcome of the planning groups' efforts was the decision to field a Combined Arms Regiment in each division.

The Combined Arms Regiment (CAR) is the focus of this thesis. The CAR has created many challenges and questions for the Marine planners. It is designed to be the first permanently standing mechanized infantry unit in the division. Its goal is to increase the mobility and firepower of the (now smaller) division. This exchange of manpower for technology is caused by the proposed 159,000 man cap on the Corps manpower. Beyond increasing the tactical mobility of the division, which was the primary goal, little had been decided about the CAR.

Superimposed on the development of the CAR are issues that challenge its very existence. The first issue is what type of vehicle should be used to carry the infantry. Additionally, the Marines must be concerned with how the CAR improves their ability to perform their role and function in the national strategy. Questions have risen as to the geographic location of the world where it is needed. In fact, some Marines have begun to doubt the utility of the CAR at all, so the question of whether or not the Corps really needs it has come to the forefront. This research is organized to provide a background discussion and then develop a baseline operating cost for comparison of the possible solutions.

B. OBJECTIVE AND SCOPE

The goal of this research is twofold, first to examine the need for the CAR as an organization within the Corps by looking at what capabilities it provides the Division, and second, to develop a baseline operating cost for the CAR under certain organizational structures. This information will provide a foundation for Marine planners to begin the detailed and complex analysis that will ultimately decide the fate of the CAR.

To achieve this objective, the role of the Marine Corps in support of the national strategy must be defined, at least in broad terms. Next, the ability of the CAR to support the Marine Corps' National Strategy role must be identified so that some measure of its value can be determined. Once this is complete, the analysis will focus on the proposed force structures for the CAR and the vehicles within them. From that point, a measure of the cost to operate the various organizations can be developed that will serve as a base for comparison. It must be understood that this document is only the beginning of research about the CAR and is not intended to provide the final answer to all these questions.

C. METHODOLOGY

Basic information for this study was obtained from current publications and trade journals. Additionally, since the CAR is such a current concept, little of the detailed information about it is in writing. This required extensive interviews with program managers, action officers, and force planners to document most of the information related to the CAR. The historical cost data used in this report came from the Marine Corps Cost Factor Manual and from supply officers associated with the operation of the various units that will eventually be associated with the CAR. The capstone information source for this report has been the Center for Naval Analysis (CNA) whose detailed analysis have proven invaluable. It must be noted that most of CNA's final documents receive security classification due to some aspect of the report, for example, survivability. Yet, some of the information contained in a CNA report is unclassified and can be recovered if the researcher is willing and able to sort through the reports. Once the data was collected it was sorted and evaluated based on the author's professional experience as a Marine officer. The bulk of this work is a simple comparison analysis of doctrine, vehicles, and structure options. Other analysts may develop different results due to their experience and different perceptions of the problems involved of those interviewed.

D. SUMMARY OF THE CHAPTERS

Chapter I defines the problem and scope of research to be conducted and explains some terms. This chapter also provides a technical description of the vehicles compared in this study. Chapter II provides an overview of how the Marine Corps fits into the national strategy. Chapter II also discusses the CAR and its possible structures. Chapter III introduces the various aspects of cost estimating and the concepts used in this study. Also examined in Chapter III, are the constant cost elements of the CAR. Chapter IV develops the Life Cycle Cost of the vehicle options considered for the CAR in this study. Chapter V, discusses the additional capabilities that a CAR would provide the division commander. Finally, Chapter VI, provides a conclusion and recommendations. Appendix A is a glossary of commonly used Marine Corps acronyms.

E. TERMS AND MAINTENANCE

1. Terms

The Commandant of the Marine Corps defines a service's ROLE as the broad and enduring purpose for the service which was established by Congress in Law (Specifically Title 10, U.S. Code). FUNCTIONs are those more specific responsibilities assigned to a service through Executive orders which permit it to successfully fulfill its legally established role. A CAPABILITY is the ability of a properly organized, trained, and equipped force to accomplish a particular function effectively. The MISSION is the task assigned by the Secretary of Defense (Mundy, Armed Forces Journal 1992, p.52).

2. Marine Corps Maintenance

Marine Corps maintenance is organized into three categories which are separated into five echelons. The categories will be explained first and then the echelons. Lastly, this section will discuss special concepts related to the CAR.

The three categories of maintenance are, Organizational, Intermediate, and Depot. Organizational maintenance is performed by the unit's mechanics on its own equipment. It includes both scheduled Preventive Maintenance (PM) and unscheduled maintenance required to keep the equipment both operational and in good condition. Organizational maintenance is sub-divided into two echelons. The next category is Intermediate level maintenance. Normally, it is performed by specially designated activities in support of field units. In this level, subassemblies and end items are replaced or repaired. Intermediate maintenance also has two echelons of maintenance. The highest maintenance level is Depot maintenance. Usually this level is performed only at Albany, Georgia and Barstow, California, the two Marine Corps Logistics Bases. Depot level maintenance has only one echelon and consists of major overhauls, and the rebuilding of parts, assemblies and end items.

a. Echelons of Maintenance

As stated earlier, the categories of maintenance are divided into five echelons. First and Second echelon maintenance are performed at the Organizational level. First echelon maintenance is user maintenance designed to be preventive in nature. It consists of cleaning, inspecting, and lubricating the equipment to keep it operational. Second echelon is the next step and is performed by trained mechanics. This is the first stage where corrective maintenance (CM) can be performed and also includes the regularly scheduled PMs. Most units in the Marine Corps have authorization to do first and second echelon maintenance with the battalion. In the intermediate level of maintenance are the next two echelons of maintenance. Third echelon maintenance is performed by designated mechanics as prescribed by maintenance publications. At this echelon, mechanics replace unserviceable components, perform very limited repair of components, and have increased diagnostic and test capabilities. Fourth echelon maintenance is usually provided by a combat service support element within the Force Service Support Group (ie., Maintenance Battalion). Mechanics at this level have the capability to do overhauls, rebuilds, and repair of major components. The highest level of maintenance is Depot which is also the fifth echelon of maintenance. These mechanics can perform any repairs not included in the other four echelons. At the fifth echelon the major end item can be completely rebuilt or in many cases parts fabricated. Normally major end items such as tanks or Light Armored Vehicles (LAV) will have one major overhaul at the depot level during a twenty year service life.

b. SECREPs

Another maintenance term the reader should be familiar with is Secondary Repairable (SECREP). These are components of major end items like alternators, carburetors, and starters. They are maintained in the maintenance float of the FSSG's Supply Battalion. SECREPs are removed by second and third echelon mechanics and exchanged at Supply Battalion for serviceable components. This system is designed to limit the down time of the effected major end item.

c. Maintenance Within the CAR

Many battalions in the Marine Corps only have maintenance authorization for first and second echelon maintenance, this includes infantry battalions. The other elements of the CAR are different in that the current tank, Amphibious Assault Vehicle (AAV), and LAV units all have third echelon maintenance at the battalion level and first and second echelon at the company level. Often a mechanic has the same Military Occupational Specialty (MOS) for both second and third echelon work, so much of the time mechanics are pooled into one section to ensure optimal use and assigned to companies when deployed. Within the CAR, large pools of mechanics are also available from the regiment Headquarters and Service (H&S) company. For this research it will be assumed that the mechanics will not be a separate third echelon shop, but be there to support the regimental headquarter's vehicles.

Another important relation to understand is how maintenance is budgeted. Currently, many units only keep track of repair cost for first and second echelon maintenance. Third echelon maintenance and SECREP costs are tracked and budgeted for by the FSSG. In effect, the operational units don't have to budget for third echelon maintenance. In this thesis, the Life Cycle Cost (LCC) is developed using a cost factor calculated by each battalion for the first and second echelon maintenance. This includes fuel, lubricants, and other stock items maintained within the organizational level of maintenance. A separate cost factor developed by the Deputy Comptroller at First FSSG is used to estimate third and fourth echelon maintenance and SECREPs costs. It is presented separate from the LCC developed for the CAR's units because the FSSG actually budgets and pays these costs.

F. VEHICLE DESCRIPTION

This section introduces the characteristics of each of the key armored vehicles involved in the CAR. It is intended to provide a reference point so that a better feel for the capability of each vehicle can be achieved. It also sets the baseline cost if available for each vehicle involved.

1. M1A1 Abrams Tank

The M1A1 has been the main battle tank of the U.S. Marine Corps since 1991. (The A2 variant is currently the U.S. Army's main battle tank.) The M1A1 has a four man crew and a 120mm main gun with 40 stored rounds. Additionally, it carries one 50 caliber machine gun and two 7.62 mm machine guns for use by the crew. The combat weight of the M1A1 is 126,003 pounds or around 63 tons. It has an overland speed of 41 miles per hour and a 309 mile range. There are normally 58 M1A1 tanks in a Marine Corps Tank battalion with an acquisition cost in FY93 dollars of approximately 3.4 million per tank. Presently, the two tank battalions each have 44 tanks, but for this thesis the normal amount of 58 is used. Yet, it must be noted that the M1A1 common tank production line has been shut down and would take at least 30 months to begin production again due to the over 18,000 vendors involved. Since the Marine Corps doesn't have it's full requirement for M1A1 tanks, it is attempting to buy old M1A1's from the Army as the Army buys the A2.

2. LAV

The Light Armored Vehicle family has had active units in the Marine Corps since 1983. The primary USMC vehicle is the LAV 25, which has a three man crew and a maximum capability to carry six additional troops or four combat loaded troops. It's combat weight is approximately 14 tons. The LAV 25 is armed with a 7.62 mm machine gun and an automatic 25 mm Bushmaster chain gun, for which it carries 630 rounds. Its land speed is 65 miles per hour with a range of 427 miles. Although it is not surf capable, it can swim at speeds of 6.5 miles per hour in calm waters. The first vehicles were delivered in 1983 and they are expected to have a 20 to 30 year service life. Currently, the Marine Corps has 758 vehicles in the following variants: LAV 25, LAV(R) Recovery, LAV(L) Logistics, LAV(M) Mortar, LAV(C) Communications, and an LAV(AT) Anti-tank. It also plans to buy some Air Defense,LAV(AD), variants.

A Personnel variant of the LAV is currently being used by the Canadian military. The Canadian vehicle is called the "Bison" and has similar characteristics to the current LAVs. It looks similar to the present Logistic vehicle used by the Marines and will carry eight combat loaded troops plus a two man crew. Should the Marine Corps use LAVs as the Armored Personnel Carrier (APC) for the CAR, it will be similar to the Bison in most respects, but the exact final configuration has yet to be determined. The acquisition cost for an LAV 25 in FY93 dollars is approximately $906,679 from the standard cost manual (versus the $1.1 million cost estimated by the program manager) and approximately $553,403 for a Logistic vehicle. Due to the competitive nature of the defense industry, no personnel variant purchase costs are releasable, but for the purpose of this analysis it will be set at $730,000 which is the average of the current Logistic variant which is most similar to the Bison and the LAV 25, which is the most common variant in the Marines. This assumption is based on the currently open production line for LAV 25's, and the fact that most of the Research and Development cost have been completed by General Motors Diesel Division, the present prime contractor. It is expected that both of the Light Armored Infantry (LAI) battalions within the CAR will have three LAI companies with four LAV 25's, 13 LAV(P)'s, 2 LAV(L)'s, and 1 LAV(R)'s each.

3. AAV 7

This is the current amphibious assault vehicle, which has been in service with the Marines since 1971. All variants of AAV7 are in service with the Marines. This includes the Personnel, Recovery and Command variants. Presently, there is no active production line, and the last delivery was made in FY85. Should more vehicles be required, it would result in significant startup cost. The AAV7(P) has a three man crew and a maximum capacity of 25 troops or 18 combat loaded troops. The current upgunned AAV has one 50 caliber machine gun with 1200 stored rounds and one 40mm automatic grenade launcher. When combat loaded the vehicle's weight is approximately 26 tons. It's maximum land speed is 39 miles per hour with a range of 300 miles. In the water it has a speed of 8.4 miles per hour and is surf capable. The AAV has gone through some block upgrades and is now designated the AAV7A1 but it's service life is expected to end in 2004. Several more upgrades have been considered including the replacement of the suspension to improve overland speed, replacement of the hull to improve water characteristics, and the changing of the armorment to a 30 mm automatic gun. These upgrades are only plans as the Advanced Amphibious Assault Vehicle (AAAV) program moves along to develop a AAV replacement. The current AAV(P) replacement cost from the Cost Factors Manuel is $1,016,079 (FY93).

4. AAAV

The Advanced Amphibious Assault Vehicle is the future result of the AAA concept program. The current goal is to have an AAV in service by 2010 or as early as 2005. The AAAV is to be a high water speed (20 miles per hour), high land speed (comparable to the MIAI tank), vehicle with increased survivability and firepower over the present AAV. Several models have been considered, and prototypes have been tested to prove the concept. The AAAV will allow an over the horizon (OTH) assault to be conducted by Marine Amphibious forces. Based on current information, and for the purposes of this study, the future AAAV will have characteristics as follows: It will have a road speed of 45 miles per hour, a three man crew, and capacity for 18 combat loaded troops. It should have a combat weight of approximately 32 tons and will be armed with a 30 mm automatic cannon with 375 stowed rounds. It is expected to have a unit cost in excess of $2.5 million.

G. SUMMARY

Chapter I has developed the thought process which this thesis will follow. It has discussed both the method of research and the sources for information. It has also explained the goal of this research and how it will be achieved from the data available. Lastly, Chapter I provides an introduction to the terms used by the Marine Corps and describes the vehicles involved in this study. Chapter I is the foundation and road map for the rest of the thesis.

II. U.S. MARINE CORPS' ROLE IN NATIONAL STRATEGY

A. DEVELOPMENT OF MARINE CORPS ROLE

The 82nd Congress enacted Title 10, U.S. Code into law in the fifties and the U.S. Marine Corps' role in the support of the Nation strategy has been well defined since. But, the collapse of the Soviet Union has forced all the Services into a period of serious internal review and reflection. Title 10 has guided Marine Corps planners since the post Korean War days and clearly defined the Marine Corps size and mission. Title 10 legislates the size of the Corps to be three combat divisions, three aircraft wings, and other elements required to support them. The law also describes the Marines as a force most ready when the nation is least ready. It is a balanced force in readiness for a naval campaign and at the same time, it is a ground and air striking force ready to suppress or contain international disturbances short of large scale war (Mundy,Proceeding 1992, p.69). The ultimate goal in having this capability is to have a force that can rapidly respond to a crisis and then prevent its growth by holding the aggression in check while America mobilizes. What developed from this concept is the current Marine Corps force structure and philosophy of high readiness, mobility, and rapid response.

In August of 1990, at Aspen, Colorado President George Bush announced the foundation for a new national strategy based on a changing world situation. The President directed a strategy based on the following corner stones: Strategic Deterrence, Forward Presence, Crisis Response, and Reconstitution. This was, of course, in response to the changing of the threat from a single foe, the Soviets, to a focus on regional areas of interest and many possible threats.

The National Military Strategy of the United States specifically identifies a Marine Corps role in both Forward Presence and Crisis Response. Next, Military planners began to develop a base force concept to support the newly defined national strategy. One of the key documents from this process has been the "From the Sea" White paper.

"From the Sea" was written by the Secretary of the Navy, Sean O'Keefe, in conference with the Navy's Chief of Navy Operations and the Marine Corps' Commandant. This document changed the Navy's focus from an open ocean "Blue Water" strategy to one that emphasizes forward operations in the littoral or areas closer to the shore. This is a deviation from the strategy of A.T. Mahan, which in general has guided the Naval service for much of the century, to one that emphasizes jointness, with a heavy lean towards expeditionary forces. A key point in "From the Sea" is its discussion of tailoring forces to the nation's need, which to the Marines translate into task organizing it's resources to complete the assigned task. This ability to build the required capabilities into a unit as needed is one of the cornerstones of current Marine Corps operating forces. "From the Sea" states that "Power projection requires mobility, flexibility, and technology to mass strength against weakness." These are of course foundational attributes of the current Marine Corps. The White paper clearly puts a very high premium on readiness, mobility, flexibility, and jointness. The first three attributes were directed to be vital qualities in the Marine Corps since 1952. It was the viewpoint of many Marines that "From the Sea" only reinforced the ideas and concepts already found in the Marine Corps. It was wrongly hoped that the Marines' core philosophies and qualities, would protect the Marine Corps from much of the pain of the force reductions. In reality the force reduction became much deeper than had been expected. It quickly became clear that simply reducing the size of the Marine Corps and doing business the same old way was impractical.

B. THE RESTRUCTURING

Without the benefit of a single clear potential threat to justify the services existences, and with the U.S. Congress pressing for a force reduction, the Commandant, General C.E. Mundy, Jr., began the restructuring process in August of 1991. The first step of the plan occurred during the senior officer retreat where the Marine Corps' leaders discussed ways to keep the force relevant , ready, and capable while conducting the force drawdown. From these discussions, two groups were formed, one active duty and one reserve, to conduct the review and build the new Marine Corps force structure.

1. The Force Structure Planning Groups

These two groups became the Force Structure Planning Groups (FSPG) and moved on to the next step. General Mundy gave the groups several specific guidelines to follow;

1. Define the most effective force at the expected 159,000 man level.
2 Maintain the Title 10 provisions and structure.
3. Ensure the MAGTF concepts are maintained.
4. Be able to field a joint task headquarters. (Krulak, 1992, p.15)

During the eight week review, the FSPG 's determined that, even with the changing world situation, a need still existed for an expeditionary, combined arms force like the Marines. As a result of the Commandants guidance and the above stated feeling, the FSPG decided to build a force that continued the traditional strengths of the Marine Corps vise develop new capabilities. The restructuring was done as a zero-based review rather than simply piecing together men and equipment to meet the fiscal constraints. Once the restructuring plan was developed, it was presented to sixty-five of the total seventy general officers to gather their feedback about assumptions made and to validate the recommendations.

The last steps of the restructuring were briefing the plan to Washington planners and then implementing the plan. Two things were made clear to the national leadership: capabilities would be lost as the size of the Corps was reduced, and the operating tempo would increase. In December of 1991, General Mundy approved the plan as the blueprint for the future Marine Corps. The plan's time table was set to conform to the six year cycle of the Future Year Defense Plan (FYDP) of the Planning, Programming, and Budgeting System (PPBS) used by the Department of Defense.

2. The Restructuring Plan

The restructuring plan touches every aspect of the Marine Corps' organization and it has far reaching effects to every level of the force structure. The forces that make up the Marine Corps fall into two major groups Fleet Marine Force (FMF) and non-FMF. FMF units are the operating forces available for deployment to meet a world crisis . They are the combat and combat support units that are the Marines fighting capability. non-FMF units are the supporting establishment which provides services ranging from training to recruiting. These forces are not available or considered when building deployable Marine Air Ground Task Forces (MAGTF). The plan looked at the Non-FMF force structure to see if any of the overhead costs of the Marines could be reduced. The non-FMF force structure was defined to include the following;

1. Marine Security Guard Battalion (provide embassy security)
2. Marine Corps Security Forces (barracks and sea duty Marines)
3. Marine Support Battalion (national level intelligence support)

4. Presidential and National Level Support
5. External Billets
6. Training Establishments
7. Bases and Stations
8. Headquarters Marine Corps (HQMC), Marine Corps Combat Development Command (MCCDC), Marine Corps Systems Command (MCSYSCOM)
9. Recruiting
10. Active Force with Selective Marine Corps' Reserve (Krulak, 1992, p.16)

In all, the non-FMF manning was about 46,000 Marines out of the total 159,000 Marines left after the expected force reduction. These non-FMF organizations were cut to the bare operating minimum to allow more room for FMF units, which are the heart of deployable Marine forces. The three Marine Aircraft Wings (MAW), which provide the assets for the Air Combat Element (ACE) were reduced from a notional size of 14,000 Marines to 12,000 each. The two CONUS-based Force Service Support Groups (FSSG) which provide the Combat Service Support Element (CSSE) for the Marines was to remain at about 8,000 troops while the third FSSG will go from battalion size units to company size units. The three Marine Divisions will drop from a notional 17,300 Marines to around 14,000 each. One of the major changes in the future division is the establishment of a Combined Arms Regiment as a means of providing greater lethality, mobility, and combat flexibility for the division commander in the smaller division. (Krulak,1992, p.17) The Combined Arms Regiment (CAR) is to have the existing divisional tank battalion, two light armored infantry battalions, and a Light Armored Reconnaissance (LAR) Company, (which is structured the same as those currently in the Light Armored Reconnaissance Battalion) under one regimental headquarters. This is the first standing mechanized infantry unit for the Marine Corps and the focus for the rest of this study.

C. THE COMBINED ARMS REGIMENT (CAR)

The CAR is a concept at this point, which is hoped to increase both the mobility and firepower of the smaller Marine division in a mid to high intensity conflict. It's roots come from the Corps' belief that it's total end strength would be capped at 159,000 Marines. The 159,000 man Marine Corps would require the reduction of several battalion size units form the division's force structure.

The original planning would place one CAR in each division, or at least one per coast. It would replace the three infantry battalions of a current regiment, removing one completely and leaving the other two with slightly smaller personnel strengths. The smaller battalions would be mounted in Infantry Fighting Vehicles (IFVs) or Armored Personnel Carriers (APCs) to increase mobility, firepower, and survivability. Additionally, the division's tank assets would be grouped under the CAR's commander to monopolize on the synergy of armored vehicles in combat. It was also accepted that the APC crews would be organic to the infantry unit to develop close relationships for both training and combat. This organization is unique because traditionally Marines task organize themselves into MAGTFs to fit the needs of the situations.

As the concept of the CAR matured and more detailed analysis was performed, several problems emerged. First, what should the APC be for the CAR, the originally suggested LAV or the AAV which was already the division's APC. Second, how would the CAR be deployed since amphibious assault lift was decreasing and no provisions were made to allow space for a CAR on the current Maritime Preposition Force (MPF). Third, was it necessary to have both CAR's structures be mirror images of each other. This problem is influenced by both the declining resource pool and decreased availability of amphibious lift. Lastly, should the tank battalion be maintained as a general support asset for the division as is the current practice? To understand this idea it must first be understood that Marine units are either in direct or general support status. Direct support is when a unit is assigned to support one other unit as its regular function. Artillery units are examples. General support is used due to the limited resources available to a division commander where some of the battalions are not directly assigned to support an infantry unit. The Tank battalion, Combat Engineer battalion, Amphibious Assault battalion, and Light Armored Reconnaissance battalion are all examples of units in general support of the division. These units are task organized by the division or MAGTF commander to fit the need of the supported infantry or scheme of maneuver.

The CAR provides both heavy punch and highly mobile infantry, giving the division commander additional battlefield options. Simply defined, the CAR's mission is to fight to a decisive conclusion with the enemy. It will have the ability to attack, seize, and defend any objective assigned to it by the division commander. It will not act like a Army Armored Calvary Regiment whose primary mission is to screen the main force by holding the enemy at bay. Additionally, its units will be built upon rather than be building blocks for the MAGTF. What remains to be determined is if the CAR will be the initial amphibious assault or if it will land at some time after the initial assault. The CAR's ability to perform an amphibious assault is a function of the shipping available and the vehicles within the CAR. This analysis focuses on the vehicle selection as that will determine what shipping program the Navy should pursue to support the Marines.

Several options have been looked at for the CAR's structure but currently only three remain. The CAR(LAV) has the personnel carrier variant of the LAV as the infantry's APC. The next option is the CAR (AAV to AAAV) which uses the current amphibious assault vehicle (AAV7P) as the APC which would then be replaced by the Advanced Amphibious Assault Vehicle (AAAV) when it enters service around the year 2010.

The last option is to have a Light Armored Infantry (LAI) Regiment instead of a CAR. This organization would have no tanks but would have two LAV mounted infantry battalions and a LAR company. This last option will not be specifically addressed in this report, but it does fit the amphibious lift constraint as a follow-on echelon because of the required additional assets required for ship to shore movement. This LAI Regiment could easily formed into a MAGTF but would require attachments. Additionally, this organization is still not compatible with the present MPF load plans.

D. THREAT DESCRIPTION

In 1989, the Marine Corps Intelligence and Warfighting Center evaluated 69 countries as potential areas for the future operations. A summary of the results of this evaluation as reported by R.D. Steele follows. The terrain in these countries was found to be equally divided into mountains, desert, jungle, and urban environment. Only about 60% had limited roads, and the average bridges were rated at 30 tons or less. Only 50% of the countries had usable ports, and there exists a significant shortage of usable military quality maps. Yet, even the countries with little infrastructure had capable militaries. On the average, the Marines could be expected to face trained infantry with modern armor and artillery. They also should expect the country to have high performance aircraft with stand-off munition capabilities. Lastly, the average line of sight for direct fire weapons was determined to be only 1000 meters.

From Steele's summary it is clear that Marine forces will have to be both highly mobile and very survivable. The Marines must anticipate that whatever vehicle they use, it should be light (30 tons or less) and capable of cross terrain movement. (All wheel drive or tracked). Additionally, if the vehicle cannot move itself from ship to shore, then the ships must have sufficient capability to off load them in stream. This becomes a serious consideration when the equipment is loaded on civilian shipping which normally does not have that capability (MPF shipping has limited in stream capability).

E. SUMMARY

The Marine Corps continues to view itself as the Nation's force in readiness. The evaluation of the national strategy and the Marine Corps' role point to a future Marine Corps that is quickly deployable to any area of the world. A Marine Corps that must be capable of clearing the way for more assets or providing a stilling effect to a crisis. The Marines will be the Nation's 9 1 1 emergency service that provides a forward presence against a capable hostile foe where ever that may be (Mundy,1993, p.13).

To do this, the Corps will have to stick to what it does best, building MAGTF's to fit the crisis and task at hand or task organizing the Marines operating forces. The components will need to be both light and flexible while able to fight a decisive battle. The Marines must follow the expectation of Title 10, and "From the Sea" by providing the Nation a fighting force that has strategic agility. Able to quickly move anywhere on the globe in an expeditious manner and fill the task assigned by the President as he requires. To do this the equipment must be compatible with available shipping and airlift. Once they get to the mission area this same equipment must be able to stand-up quickly and provide a strong enough deterrence to extinguish the fire without repressing the local people. This is how this study defines expeditionary forces.

The CAR provides a tool that gives strength to Marine Expeditionary Force (MEF) sized MAGTF's when faced with highly sophisticated enemies. The CAR also creates a pool of mechanized infantry trained Marines, able to work more effective in the mid to high intensity conflict area. Yet, the CAR fails to fit the presently available shipping assets. This strips the CAR of much of its speed in strategic deployments and places it in the Follow Echelon role for Marine planners. Even if Maritime Preposition Force (MPF) shipping is expanded to lift the CAR, by accepted planning estimates it is a ten day wait before the CAR's equipment would be off loaded in a battle area. This shortfall alone maybe a critical blow to fielding a CAR even with the added capability it provides the force. If this shortfall can be overcome then the CAR would be very useful in future high intensity conflicts.

What is important to understand about this discussion is that the CAR concept may not fit the role the Marine Corps envisions for itself or is expected to perform. The CAR concept is an exceptional ideal to provide a heavier more tactically mobile combat force within the Marine Division. On the other hand, the CAR is realistically to cumbersome to rapidly deploy to a crisis spot on short notice. As good as the CAR concept is, it may be a tool to fight the last war and not the conflicts of the nations future. This provides the back drop for the next chapter which moves the discussion of the CAR's usefulness into the cost of its elements.

III. DEVELOPMENT OF COST

A. INTRODUCTION TO COSTING

The reason for developing cost estimates is the realization that resources are limited or as the Department of Defense has found, shrinking. Stewart describes cost estimating as a way to allocate resources and the objective of cost estimating as being a way to describe the cost of using a combination of resources to achieve a desired level of service (Stewart, 1991, p.2). He categorizes cost estimating into either a parametric "top-down" approach or a industrial engineering "bottoms-up" approach. The parametric method uses historical data and is normally done early in the life or development of a program. The industrial engineering approach is used later in the program's life and requires detailed estimates of all the sub elements of the program. It is therefore expensive, time consuming, and difficult to do. The parametric method is normally relatively quick to do but is limited because it often falls to directly associate costs to specific elements of the program.

In developing a cost estimate, there are several accepted methods: detailed estimating, direct estimating, estimating by analogy, quotes, learning curve theory, statistical methods, and handbook estimating. Each has advantages or disadvantages based on the information available and the estimators skill. In estimating the CAR's cost, direct estimating, quotes, and learning curve theory were ruled out because of the lack of detailed information and the poor definition of the units organization. The use of detailed estimating methods required the specific components of the CAR be known which to accurately measure is a massive and time consuming project. For this reason detailed estimating was ruled out. This leaves statistical methods and handbook estimating. Presently the U.S. Army operates many mechanized infantry organizations which perhaps could be used to develop a statistical estimate for the CAR. The author choose not to use this method because of the differences between the way the Army develops its costs and operates its units. Handbook estimating was selected because the Marine Corps has developed internal cost factors that apply more specifically to the organic units of the Marines. The best currently available estimating source is the Marine Corps Cost Factor Manual which is the standard handbook of all the accepted cost factors used by the Marine Corps. Extracting the CAR's cost from the manual by using similar units or standard costs allows a description to be made of the CAR's expected cost. This is a combination of the handbook and analogy estimating methods. These methods are acceptable during the early stages of a project when the specifics of the project are only generally defined, which is the CAR's situation. There are some pitfalls in this method, because the values taken from the handbook may not completely or accurately reflect the actual item being estimated. Also the handbook estimates generally do not produce estimates with as much detail as can be achieved through other methods. Therefore, this method produces only a starting point or baseline cost. The advantage of handbook estimating is that it is quick and can be applied to a wide variety of situations. This estimate will help determine the economic feasibility of the CAR. Future evaluators should understand that much of the estimate is based on the author's experience and personal judgment as to the similarity between current units and the future CAR's units.

1. Fielding Cost Calculations

The first aspect of the CAR that will be estimated is the initial start up cost, or fielding cost. Under this area, the cost to put the vehicle, either LAV or AAV into the CAR will be developed from the cost manual or program coordinator estimates. Also, under this cost will be the CAR's equipment. Equipment will be broken down into individual equipment cost and organizational equipment cost. The individual equipment cost include the individual's weapon and personal "782 gear". Organizational equipment includes everything else that must be bought with appropriated Marine Corps dollars, except the armored vehicle. This distinction is made because the vehicle cost is being estimated separately as well as compared between the two proposed CAR's. A cost factor for organizational equipment will be developed from the Cost manual . The current standing unit's organizational equipment value is broken out in the manual. From that value the standard unit price for each vehicle can be summed and subtracted out. This leaves only the value of the organization equipment required to support the number of vehicles in the unit. This organization equipment cost minus vehicles can then be divided by the number of tanks, LAV's or AAV's in the battalion to develop an organization equipment cost factor. This factor is then multiplied against the expected number of vehicles in the CAR to estimate it's organization equipment cost.

2. Life Cycle Cost Calculations

To develop the CAR's cost, this thesis will focus on the organizations Life Cycle Cost (LCC) over a twenty year period. For the purpose of this thesis, the LCC estimate will include personnel cost, maintenance cost, and ammunition cost. Personnel cost is the average cost from the standard cost manual for the enlisted and officer personnel converted to fiscal year 1993 values.

Maintenance cost will be developed from an organization maintenance factor (First and Second echelon maintenance) developed in each of the standing units that would provide skills or equipment to the CAR. Third and Fourth echelon maintenance costs as well as SECREPs will be developed as separate costs. Depot level maintenance costs will not be considered here but often are part of LCC estimates. Ammunition cost is developed from the Cost Factors manual and with each standing unit forecast of ammunition. Each standing units uses hundreds of various ammunition types annually. To narrow the scope of the ammunition calculation only the most expensive and highest use type are included in the estimate. This allows a general estimate to be developed without estimating every type of ammunitions used by the unit. Some types of munitions were left out because the use rates are based per weapon. If the number of weapons in the organization could not be accurately estimated then the ammunition was not estimated. This was the case with the Shoulder Launched Multipurpose Weapon (SMAW).

3. Definition of Work

Now that the items or areas to be costed have been identified, the next step is to define the work. To develop the CAR's estimate, or any cost estimate, the scope of work or work breakdown must be clearly defined. Since no organization like the CAR exist in the Marine Corps, the first step is to develop the stand-up cost or fielding cost of the various CAR components. To facilitate the development of the estimate, each unit will be estimated at one level below the level that they would be employed tactically. For example the LAR Company cost will be presented as a cost for the total company but the details were developed from the cost of individual platoons. In some cases when estimating the cost of the CAR alternatives the estimates were based on individual vehicle cost, for example, crewmen. Once the cost of each CAR's components is developed and summed at the battalion level, the total estimated peacetime operating cost for twenty years can be calculated.

This estimate will not reflect the cost associated with the CAR or Marine Corps operating tempo. The individual cost of training exercises could not be factored in because of the variability between Marine Corps units based on location. Although maintenance costs in some respects are dependent on the amount of time a unit spends in the field, average maintenance costs will be used. Another aspect of this estimate is that some costs are either the same between the old division structure and the new or at least the same between the proposed CAR structures. The infantry organization is the primary cost that does not change between the division with or without a CAR. Additionally, the cost for the tank battalion, and Light Armored Reconnaissance (LAR) Company are the same between various CAR structures. The estimate will represent the additional cost to the Marine Corps to operate one CAR's worth of additional armored vehicles plus the cost of the current, in place, force structure.

4. Constant Cost Elements

This section will discuss those costs that are special cases or are similar in both CARs and old or new division structures. Here the term constant cost refers to those cost that are generated by units or components of the CAR or division regardless of the final choice of APC. It will specifically discuss the tank battalion, Light Armored Reconnaissance (LAR) Company and the cost of the infantry assigned to the CAR. In some analysis these would not be considered at all since they represent a "sunk cost". A sunk cost is one that has "already been incurred and that cannot be changed by any decision made now or in the future."(Garrison,1991,p.44). The cost of the tank battalion, Regimental H&S

Company, and the infantry has already been incurred and little can be done about them. Often sunk cost are not included in a systems cost because only the increment or additional cost is relevant. In this case since an fielding cost for the total CAR is being estimated, it is relevant to the analysis.

The cost of the LAR company is a cost that is new to the cost of operating the division and a sunk cost when comparing CAR alternatives. Although LAR companies already exist, the CAR's LAR will be an additional company.

B. TANK BATTALION COMPONENT COST

The battalion is organized into four tank companies and one Headquarters and Service (H&S) company with fifty-eight M1A1 tanks. Each tank company has fourteen tanks with five officers and ninety enlisted Marines. The H&S company has twenty-nine USMC officers, 393 USMC enlisted, two Naval officers and thirty-five Navy enlisted. The H&S company also has two M1A1 tanks and all the logistic and administrative support overhead for the battalion. Some structure will be added such as a LAV mortar platoon and LAV-25 scout platoon. Their personnel numbers are included in the H&S company's personnel strength and the vehicles would consist of four LAV-25's and two LAV(M) with 81mm mortars. One LAV(C) would also be added to the battalion.

1. Tank Battalion's Equipment Cost

The first cost to be examined in the tank battalion is equipment cost. Here equipment cost are calculated to demonstrate the method used as they do not impact on the battalions annual operating cost. Equipment falls into two categories; organization and individual. Organization equipment consists of major end items like tanks and trucks while individual equipment consists of the items issued directly to the Marine (rifle, pack, and helmet) normally referred to as 782 gear. Individual equipment is handled first because it depends primarily on the organization's personnel strength.

a. Tank Battalion's Individual Equipment Cost

The average cost per individual for 782 gear in is $779 FY90. Inflated with the procurement inflation factor of 0.8934 (by dividing) to an FY93 value of $872 per Marine or Sailor. The cost of the Marine's weapon depends on whether he is armed with the M16A2 rifle or the M9 9mm pistol. In this analysis, it is assumed that only USMC officers and the Navy personnel will carry the M9 pistol. This will result in a higher individual weapon cost overall because many enlisted Marines will actually be armed with the pistol, depending on rank and billet. The FY93 cost for an M16A2 is $713 and $273 for an M9 pistol. These costs can now be combined with the 782 gear cost to create an individual equipment cost for the tank battalion:

839	personnel in battalion
x872	dollars to outfit one Marine with 782 gear
$731,608	Total Cost Of 782 Gear For Tank Battalion

86	personnel armed with M9 x $273 per weapon =	23,478
753	personnel armed with M16A2 x $713 per weapon =	536,889
	Total Cost of Individual Weapons =	$560,367

Thus, the total cost for a tank battalion's individual equipment is $1,291,975.

b. Tank Battalion's Organizational Equipment Cost

The issue of organizational equipment is much more difficult to address because unit's often have slightly different tables of equipment. For this analysis the primary weapon system in a tank battalion is the M1A1. It will be considered as the main cost driver, with all other organization equipment added to it as a factor similar to overhead. This is a reasonable assumption because every piece of equipment in the unit is designed to in some way to help the tanks perform their mission. The cost manual describes the cost for the old M60A1 tank battalion which fielded seventy M60 tanks. The M60 tanks standard unit price is subtracted from the battalion's organizational equipment value of $100,360,000 FY90 for a remaining organizational equipment pool value of $37,867,850 which then must be inflated to a FY93 value of $42,386,221. Now the organizational equipment factor is developed by dividing this value by the original seventy tanks for a factor of $605,517 per tank. Next the factor is multiplied by the fifty-eight M1A1 tanks in the CAR tank battalion to create a total estimate of $35,119,986 worth of organizational equipment. Additionally the cost of the tank battalions new organic LAVs must be added to the tank battalions total. The LAVs will cost approximately $5,491,799, bringing the tank battalion's total organizational equipment cost to $40,611,785 FY93. The LAV cost comes from the standard vehicle costs which are examined in the section about the LAR company. The disadvantage of this method is that it fails to identify the fixed and variable cost within the tank battalion. This is important because some of the organizational equipment is the same regardless of the number of tanks in the battalion.

Additionally, the fielding cost for a tank battalion is approximately $41,903,760 without the cost of the M1A1 tank (which cost approximately $3.4 million each) and facilities. This type of analysis will be used to calculate all the following units. The next section will begin the development of the Life Cycle Cost (LCC).

2. Tank Battalion's Personnel Cost

The first LCC element to be examined is the cost of personnel. The total number of officers and enlisted in a tank battalion is:

	H&S	COMPANY(x4)	TOTAL
USMC Officer	29	5	49
Enlisted	393	90	753

USN	Officer	2	0	2
	Enlisted	35	0	35

The cost factor manual provides the Annual Average personnel cost in FY90 dollars which must be inflated to reflect the FY93 base used in this analysis. The cost factors manual also provides inflation tables for various cost categories discussed in this thesis.

		FY90	INFLATION RATE	FY 93
USMC	Officer	59,116	0.89896	65,760
	Enlisted	24,971		27,778
USN	Officer	63,761		70,928
	Enlisted	27,408		30,489

Next, simple arithmetic can be used to calculate the total personnel cost in FY93 dollars.

		Total	Cost	Total Cost
USMC	Officer	49	65,760	3,222,240
	Enlisted	753	27,778	20,916,834
USN	Officer	2	70,928	141,856
	Enlisted	35	30,489	1,067,115
	Final Total Cost Personnel			$ 25,348,045

3. Tank Battalion's Maintenance Cost

The next cost to be discussed for the tank battalion is maintenance cost. The cost of required organizational maintenance is dependent on the amount of operation time. Additionally, the tank battalions in each division have different operational environments which result in different total operating hours. For this analysis an average of 250 hours of operation per year will be used. This is based on interviews with tank battalion operations officers. The average maintenance cost is $200 per hour of operation, (also from tank battalion operations officers) and includes the cost of fuel, lubricant, and organizational repair parts. Therefore, for the fifty-eight M1A1's in a battalion the annual average maintenance cost is $2,900,000.

One individual equipment cost that does impact on the battalions annual expense is the cost of equipment upkeep or maintenance. This must be calculated separately from the battalions organizational maintenance cost. To develop this value, the cost manual presents a standard value of $448 FY90 for yearly upkeep. This figure is inflated by dividing it by the inflation factor for operations and maintenance which is 0.8625 and results in a FY93 value of $519. This is then multiplied by the battalions total end strength for a resulting estimate of $435,441 to annually maintain the battalions 782 gear.

Another aspect of maintenance is third and fourth echelon maintenance cost. The $200 factor only applies to the organization level of first and second echelon of maintenance. Tank battalion also has organic third echelon capability although it is not charged directly for that cost generated by function. The 1st FSSG comptroller's office must keep track of the cost of third, fourth and SECREPs cost because of the Combined Arms Exercises (BA) conducted at the Twenty-Nine Palms combat center. For these exercises, east coast units use west coast units equipment and a charge back must be used to charge the east coast units for the maintenance cost. The 1st FSSG comptroller uses these cost factors to help calculate this cost area. This author does not include the generated cost in the LCC calculation here but does total them in the LCC Summary appendix. The reason for this that the factors are based on calender use vise hours of use and that the CAR units would not be directly charged for the costs generated by these maintenance functions.

For a Tank battalion, the factor is $193 per month per vehicle for third and fourth echelon work. For SECREPs the factor is $4,391 per month per vehicle. Using these factors over twelve months for the fifty-eight tanks in the battalion produces costs for third and fourth echelon of $134,328 and for SECREPs of $3,056,136. Over a twenty year period, this produces costs of $2.7 million in third and fourth echelon maintenance and $61.1 million for SECREPs. An important note here is that the M1A1 tank is still under warranty, and the third and fourth echelon cost estimates may be lower than actual value.

4. Tank Battalion's Ammunition Usage Cost

Ammunition is a major expenditure in any military organization and is therefore included in the annual operating cost of the unit. A tank battalion manages over seventy types of ordinance so only the high use, high cost types will be used to forecast the tank battalions ammunition cost. The following list describes the types, quantities, and total cost used in this analysis.

	Type	Quantity	Total Cost
M16A2	5.56 mm Ball	67,017	14,744
	Blank	150,600	18,072
7.62 mm	Blank	104,000	28,080
	4 in 1	681,600	436,224
.50 cal	4 in 1	87,000	127,020
120 mm	TP-T	3,306	3,085,688
	TPCSDS-T	7,134	5,412,280
	HEAT-MP-T	464	1,408,364
81 mm	Illum	110	17,614
	HE	800	72,000
	Smoke-up	110	13,538
25 mm	APDS-T	1,200	20,124
	HEI -T	1,200	25,128
	TP -T	1,888	21,920

Total Ammunition Estimate $10,701,066

This allows the development of a total one year operation cost as follows:

Total Personnel Cost	25,348,045
Vehicle Maintenance Cost	2,900,000
Individual Equipment Upkeep Cost	435,441
Annual Ammunition Cost	10,701,066

Annual Estimated Operation Cost (FY93) $39,384,552

This value of $39.3 million can be multiplied by twenty years to develop a twenty year LCC of $786 million.

C. LIGHT ARMORED RECONNAISSANCE (LAR) COMPANY COMPONENT COST

The LAR consists of fourteen LAV-25, three LAV(L), three LAV(C), one LAV(R), two LAV(M) , and four LAV(AT). The company has five officers and 112 enlisted Marines organized into a Headquarters section with three LAR platoons. This organization is basically the same as currently exists in the Light Armored Reconnaissance Battalion which prior to the Persian Gulf War was designated Light Armored Infantry Battalion (LAI). The analysis conducted will include the same steps as performed on the tank battalion so only the results will be discussed here and any different assumptions that must be made.

1. LAR Company's Vehicle Procurement

The first major difference is that all of the LAR's vehicles must be procured, as they currently don't exist in sufficient quantities to support the organization. The following table lists the Replacement cost for each vehicle from the cost manual adjusted for inflation:

VEHICLE	COST(FY93)	QUANTITY	TOTAL
LAV(25)	906,680	14	12,693,520
LAV(L)	553,404	3	1,660,212
LAV(C)	625,110	3	1,875,330
LAV(R)	580,605	1	580,605
LAV(M)	619,984	2	1,239,968
LAV(AT)	1,123,306	4	4,493,224
	Total Procurement Cost		$22,542,859

2. LAR Company's Equipment Cost

The same calculations are made for individual equipment with one exception. The total exact quantity of M16A2 rifle's and M9 pistol's is known to be 104 and 13 respectively.

117 company personnel x $872 to outfit one Marine with 782 gear = $102,024

13 personnel armed with pistols x $273 per M9 =	3,549
104 personnel armed with M16A2 x $713 per M16A2 =	77,701
TOTAL COST OF INDIVIDUAL WEAPONS	77,701
TOTAL INDIVIDUAL EQUIPMENT COST	$179,725

The cost of organization equipment is taken from the Cost Factors Manual with the cost of the LAV's removed. This was easily done because of the similarities between the future LAR company and the current LAI reconnaissance company. The value of the organizational equipment is $945,293 FY93.

The result of these calculations produce a fielding cost for the LAR company of:

Vehicle Procurement	22,542,859
Individual Equipment Cost	179,725
Organizational Equipment Cost	945,293
Estimated Fielding Cost	$23,667,877

3. LAR Company's Personnel Cost

Again the first LCC element to cost out is the personnel cost which are based on the same values from the cost manual as was used for tank battalions. One note is that the LAR company has no organic Naval personnel so any needed medical corpsman would be assigned on an as needed basis from the regimental H&S company.

PERSONNEL	QUANTITY	(FY 93)RATE	TOTAL
USMC Officer	5	65,760	328,880
Enlisted	112	27,778	3,111,136
		Total Personnel Cost	$3,439,936

4. LAR Company's Maintenance Cost

The next major assumption which changes is the average maintenance cost to operate the LAV. The LAV planning figure for hourly operation is $100. Additionally, because the LAV is wheeled, making it more like a truck or car, it normally operates at rates well over 250 hours annually (Close to 400 hours). Yet, for this study 250 hours will be set as the target calculation rate for all vehicles to provide consistency throughout the report. This will ensure that when the CAR options are compared that the comparison is over the same conditions.

The planning factor for LAV operations is $100 per hour, per vehicle with 250 hours annually operations. The total number of LAV family vehicle in the LAR company is twenty-seven which results in an annual average organizational maintenance cost of $675,000. The maintenance cost of the companies Individual equipment is $60,723 based on and end strength of 117 Marines.

Here again third and fourth echelon and SECREP costs will be calculated using 1st FSSG factors. Using twelve months and twenty-seven vehicles the third and fourth echelon factor is $516 and produces $167,184 which over twenty years is $3.3 million. The SECREP factor is $464 and produces an annual cost of $150,336 and a twenty year cost of three million dollars. Here it is important to note that these factors are for the LAV-25 which is the most expensive LAV to operate.

5. LAR Company's Ammunition Usage Cost

The last of the LCC elements to estimate is the ammunition which is based on the following values:

	Type	Quantity	Total Cost
M16A2	5.56 mm Ball	9256	2,036
	Blank	20,800	2,496
7.62 mm	Blank	108,000	29,160
	4 in 1	129,600	82,944
25 mm	APDS-T	4200	70,434
	HEI -T	4200	87,948
	TP -T	6608	76,719
81 mm	Illum	110	13,538
		Total Ammunition Estimate	$454,889

All twenty-seven vehicles in the company are armed with a 7.62 mm machine gun for self defense and do not mount the .50 caliber machine gun. Each vehicle's gun requirement is used to develop the estimate. TOW missiles are not used in the estimate because of their low annual use rate (most TOW gunners are trained with simulators).

This resulting annual operation cost is:

Total Personnel Cost	3,439,936
Vehicle Maintenance Cost	675,000
Individual Equipment Upkeep Cost	60,723
Annual Ammunition Cost	454,889
Annual Estimated Operation Cost (FY93)	$4,630,548

Over the twenty year life cycle of the vehicles the LAR company can be expected to cost $92 million.

D. ORGANIC INFANTRY AND REGIMENTAL H&S COMPANY COMPONENT COST

This section will discuss the cost of the infantry structure already in place that the future armored vehicles will be superimposed on. Normal infantry regiments have three infantry battalions and a Regimental H&S Company. The current infantry battalions have three rifle companies, one weapons company, and one H&S company. The total number of personnel under this organization is 156 USMC officers, 2,879 USMC enlisted, eleven USN officers, and 205

USN enlisted. Under the CAR one full infantry battalion's forty-four officers, 861 enlisted Marines, and sixty-nine USN personnel disappear. Also the normal twelve Marine infantry squad shrinks to nine Marines, a 25% reduction per squad. Specifically, the current rifle company, which consists of six officers and 176 enlisted, changes to a Light Armored Infantry Company with three officers and 117 enlisted including the vehicle crewmen. On the other hand, the H&S company currently has twenty-one USMC officers, 180 enlisted and 69 USN personnel while the Light Armored Infantry battalions, H&S company increases to twenty-two officers, 340 enlisted and thirty-three USN personnel. Much of this increase comes from adding LAV maintenance personnel and from the H&S company assuming some of the combat support roles of the weapons company like antitank sections and scout platoons. A similar change occurs with the Regimental H&S company. To help understand the differences the following table is provided:

	CURRENT TABLE ORGANIZATION				CAR TABLE ORGANIZATION			
	USMC		USN		USMC		USN	
	(O)	(E)	(O)	(E)	(O)	(E)	(O)	(E)
Regimental Totals	156	2879	11	205	102	1954	6	87
Regimental H&S	24	296	2	7	28	320	2	25
Battalion Totals(X3)	132	2583	9	198 (x2)	74	1634	4	62
Single Bn	44	861	3	66	37	817	2	31
H&S Company	21	180	3	66	22	340	2	31
Weapons Company	5	153	0	0	0	0	0	0
Total Rifle Company(x3)	18	528	0	0	15	477	0	0
Single Rifle Company	6	176	0	0	5	159	0	0

LAI units were organized prior to the Persian Gulf War with no weapons platoon and this caused some functional problems. Most of the weapon company's assets were task organized into the LAI companies during the war to solve these problems. Currently, there is a push within the CAR planning groups to build within the CAR's LAI company a separate weapons company to facilitate this. The results would be that the same total number of vehicles (106 per battalion) and personnel will be organized differently than current expectations. In this thesis the LAI weapons company will not be developed as a separate unit because it has not been decided if it will be fielded as a separate company. In the LAI table of organization the third infantry battalion has been subtracted from the total end strength plus the nine man squad is adopted. These numbers produce a 32% reduction in available infantry (excluding USN personnel), and as displayed, include the additional 501 non-infantry personnel that are vehicle crews and mechanics. When these additional 501 enlisted Marines are subtracted they provide the real number of infantry available, assuming that every Marine is an infantryman, and the values that will be used to calculate the cost of the infantry structure.

1. Discussion of Fielding Cost of the Infantry Structure

The infantry organization is already in existence and will be reduced in size from the current organization. Therefore, there is no fielding cost incurred from the infantry portion of the CAR. The fact is that the infantry organization will take a 32% reduction from the lost troops taken by the force reduction. Due to this reduction the organization's equipment value would drop from $37.9 million to approximately $25.8 million. This cost saving would not be fully realized as much of the $12.1 million worth of equipment would probably go into storage at the Marine Corps Logistics Bases or be redistributed to other units. The savings would come in the form of reduced costs to maintain and operate the equipment. To establish a reference measurement, the cost of individual equipment is developed here. The same methods used for tank battalion also apply to the cost of individual equipment and weapons.

Total Personnel 1648 x $872 cost to outfit with 782 gear = $1,437,056

195 personnel armed with M9 x $273 per pistol	=	53,235
1453 personnel armed with M16A2 x $713 per rifle	=	1,035,989
TOTAL COST OF INDIVIDUAL WEAPONS		$1,089,224
TOTAL COST OF INDIVIDUAL EQUIPMENT		$2,526,280

2. Infantry Structure Personnel Cost

Staying in the established LCC format, the personnel costs are developed first. The without vehicle operator numbers, described in the introduction of this section, will be used to develop the cost for the infantry components of the CAR. Using the same methods as in the tank battalion and LAR examples the personnel costs of the infantry regiment are as follows:

	PERSONNEL	COST	TOTAL
USMC Officer	102	65,760	6,707,520
Enlisted	1453	27,778	40,361,434
USN Officer	6	70,928	425,568
Enlisted	87	30,489	2,652,543
Total Personnel Cost			$50,147,065

3. Infantry Structure Maintenance Cost

Annual Maintenance cost will be calculated on the cost factor manuals value of $519 FY93 per individual. Once again the assumption is made that the individual infantryman is the main cost driver.

Total Personnel 1648 x $519 = $855,312 Individual Equipment Upkeep Cost

4. Infantry Structure Ammunition Usage Cost

The ammunition estimate for the infantry elements is the most difficult to develop. The reason for the difficulty is that no clear plan exist at this time as to what weapons will remain within the smaller regiment. In this estimate current mixtures were assumed to be maintained. One example of this is the M203 grenade launcher, which currently is fielded with a mixture of one per four man fireteam. Under this mixture the CAR squad has two M203s with three squads per platoon, three platoons per company, three companies per battalion, and two battalions per CAR for a total of 108 M203s. The other main difference with the infantry's ammunition estimate is that M16A2 5.56 ball and blank ammunition has a higher use rate for infantry personnel than for vehicle crews. The infantry uses 5.56mm ball at a rate of 190 rounds per weapon rather than the eighty-nine rounds per weapon for vehicles crews. With 5.56mm blank the infantry planning factor is 400 rounds per weapon vise 200 for crewmen. The following table provides the ammunition summary for the infantry elements of the CAR:

	Type	Quantity	Total Cost
M16A2	5.56mm Ball	276,070	60,735
	Blank	581,200	69,744
7.62 mm	Blank	348,000	93,960
	4 in 1	417,600	267,264
M203 40 mm	WSP	540	11,086
MK19 40 mm	HE-DP	600	12,894
60 mm	Illum	720	26,914
	Smoke-WP	324	21,867
	HE	7200	397,224
81 mm	Illum	880	140,914
	HE	6400	576,000
	Smoke-up	880	108,302
		Total Ammunition Estimate	$1,813,184

This goes into the LCC calculation which are presented in tabular from:

Total Personnel Cost	50,147,065
Individual Equipment Upkeep Cost	855,312
Annual Ammunition Cost	1,813,184
Annual Estimated Operation Cost (FY93)	$52,815,561

The expected twenty year LCC is estimated to be $1,056 million.

E. SUMMARY OF CONSTANT COST ELEMENTS

Three elements of any CAR are sunk or constant cost whose value does not change regardless of the armor vehicle selected to move the infantry. The combined cost to operate the CAR's tank battalion, LAR company, and the infantry structure for twenty years is $1,934 million FY 93. This of course does not include the cost of purchasing the additional LAV's and equipment required for the LAR company. Each of the individual element estimates show that personnel costs contribute the most to the overall operating costs of the presently standing elements of the CAR. The only cost reduction comes from the down sizing of the infantry force which produces an annual cost savings of more than $30 million (Personnel Cost of one Infantry Battalion) in personnel. This could pay for the cost of fielding the LAR company's LAV's and equipment.

IV. CAR VEHICLE OPTIONS

In this Chapter the various CAR vehicle options costs will be developed. The same methods used in Chapter III are applied here, but the focus is on the cost generated by either LAVs or AAVs. The AAAV is only discussed in general terms and no detailed cost estimate is provided. The first cost to be developed will be that of a CAA(LAV)'s vehicles and operators.

A. LAV BASED CAR COSTS

When the CAR was originally conceived, it was during the post Desert Storm euphoria. At that time the LAV was seen as the armored vehicle of the Marine Corps future. The two Light Armored Infantry battalions had performed extremely well with their LAV-25's in Southwest Asia. These battalions, although not truly infantry battalions, had acted in a fashion much like calvary units. So when the idea for the CAR first was formulated, the LAV was the only choice considered for the APC. This was seen as the next step in the development of the LAV family of vehicles. For this reason, the cost analysis of the CAR(LAV) will be developed first. There is presently a table of organization and an acquisition initiative (in POM 94) available to support much of the calculations. First the initial cost or fielding cost will be established.

1. CAR(LAV) Vehicle Acquisition

The acquisition of the CAR's required vehicles must be considered to determine the stand-up cost, since the CAR(LAV) is an all new organization. Each CAR(LAV) will have approximately the following quantity and mix of vehicles in it's two LAI battalions and H&S company.

	Total	Qty per Bn	Req. H&S Qty	Cost each	Total Cost
LAV 25	42	21	0	906,680	38,080,560
Personnel(P)	78	39	0	730,000	56,940,000
Logistics(L)	34	16	2	553,404	18,815,736
Command(C)	12	4	4	625,110	7,501,320
Recovery(R)	13	6	1	580,605	7,547,865
Mortar(M)	16	8	0	619,984	9,919,744
Antitank(AT)	36	12	12	1,123,306	40,439,016
TOTAL VEHICLES	231	106	19		
TOTAL VEHICLE ACQUISITION COST (FY93)					$179,224,241

The POM 94 acquisition proposal calls for the purchase of 400 plus LAV's in all variants. This would provide over 200 of the personnel variants and enough total vehicles for two CAR's but not for the MPF. The total estimated cost is estimated to be approximately $620 million with deliveries occurring from FY 96 to FY 2000. A proposal exists for the current LAV(P) or Bison to receive a .50 caliber machine gun or MK19 automatic grenade launcher station to increase the vehicles firepower but no estimates are available as to how much this would cost or what effect it would have on troop capacity.

2. CAR(LAV) Equipment Cost

Individual equipment and weapons costs are calculated in the same manner as has previously been described and result in an individual equipment value of $436,872 and an individual weapons value of $357,213 assuming all 501 Marines will be armed with M16A2's. The total individual equipment cost is $794,085.

Organization equipment costs will be allocated based on the total number of LAVs. To develop this dollar amount the organization equipment cost of the original LAI battalion will be extracted from the Cost Factors manual and distributed to the LAVs in it's organization. Here the same method is used as was used with tank battalion. This will provide a cost per vehicle that can be transferred to the vehicles in the CAR. The original LAI had 114 vehicles in all variants except the personnel model. These calculations provide an organization equipment cost of $187,473 per LAV, which in turn provides a total organization equipment value of $43,306,283 for the CAR(LAV).

3. CAR(LAV) Fielding Cost Summary

The cost to field the CAR(LAV) is a combination of the cost of the new LAVs and equipment cost. This results in a total initial cost of approximately $223.3 million. This cost is slightly inflated because almost all of the individual equipment saved by the infantry force reduction which was probably going in to storage can be transferred to the 501 personnel required for support of the CAR's LAVs. Although less than one million dollars, this allows for the use of existing equipment stocks. It should be understood that this savings applies to any CAR variant. Next, the LCC elements of the CAR(LAV) will be calculated.

4. CAR(LAV) Personnel Cost

In this section only the additional cost of the vehicle crews and mechanics will be examined as all other personnel have been accounted for under the Infantry organization structure. Crews are defined as personnel involved directly in the operation of the vehicle and in the LAV 25's case, maning the vehicle's weapons. The LAV(AT) TOW gunners, and LAV(M) 81mm mortar men are not considered here because they man basically the same system regardless of what vehicle it is mounted in and so have been grouped into the infantry structures cost.

Vehicle Type	Crew	Vehicle Quantity		Total Crew
25	3	42		126
P	1	78		78
L	2	34		64
R	2	12		24
C	2	13		26
M	2	16		32
AT	2	36		72
			TOTAL	422

Additionally, there will be approximately 79 LAV specific mechanics. The total for LAV specific crews and mechanics is 501 Marine enlisted whose cost is $13,916,77 FY93.

5. CAR(LAV) Maintenance Cost

This section will use the same planning factors as those for the LAR company with 250 hours of annual operations and $100 per hour per vehicle. This provides a maintenance cost of $5,775,000. This value is slightly inflated because the planning factor is developed from LAV 25 based units which are more costly to operate due to the 25 mm gun than the proposed personnel variant which makes up most of the CAR's vehicles. Also, the cost to upkeep the 501 operators individual equipment must be developed. This value is $260,019 when the $519 maintenance factor is applied.

To develop an estimate of the third, fourth and SECREP costs, 1st FSSG factors are used again. For the CAR (LAV)s 231 vehicles over twelve months, the $516 third and fourth echelon cost is used to generate $1,430,352 which over twenty years is $28.6 million. In the SECREP category, a $464 monthly factor is used to produce an annual cost of $1,286,208 and a twenty year cost of $25.7 million.

6. CAR(LAV) Ammunition Usage Cost

The calculations for ammunition are, done the same as has been previously described. The exception is that two alternative costs are presented. The first assumes that all LAVs will be used in the existing armament configuration with only the 7.62 mm machine gun for protection. The second alternative examines the cost of ammunition if the LAV(P) receives a .50 caliber weapon station. The first table shows the ammunition that is constant for both alternatives.

	Type	Quantity	Cost
M16A2	5.56mm Ball	44,589	9,810
	Blank	100,200	12,024
25 mm	APDS -T	12,600	211,302
	HEI -T	12,600	263,844
	TP -T	19,740	229,181
7.62 mm	Blank	468,000	126,360
	4 in 1	561,600	359,424
		Total	$1,211,945

The 7.62 ammunition is used by the LAV 25, LAV(L), LAV(C), LAV(M), and LAV(R) whose armorment will not change. The next table calculates the cost if all LAV(P)'s have 7.62 mm machine guns:

	Type	Quantity	Cost
7.62 mm	Blank	312,000	84,240
	4 in 1	374,400	239,616
		LAV(P) Specific Cost	323,856
		Constant Ammunition Cost	1,211,945
		TOTAL	$ 1,535,801

The same process is used for the .50 caliber variant of the LAV(P)

	Type	Quantity	Cost
.50 cal	4 in 1	117,000	170,820
		Constant Ammunition Cost	1,211,945
		TOTAL	$1,382,765

The .50 caliber upgrade of the LAV(P) would prove to be a less expensive system to operate because it has no blank ammunition.

7. CAR(LAV) Life Cycle Cost Summary

The following table represents the one year operation cost for a CAR (LAV) with the APC armed with .50 caliber machine guns:

Total Personnel Cost	13,916,778
Vehicle Maintenance Cost	5,775,000
Individual Equipment Upkeep Cost	260,019
Annual Ammunition Cost	1,382,765
Annual Estimated Operation Cost (FY 93)	$21,334,562

Now using twenty years produces a total LCC of $426 million. This added to the LCC values for each of the standing elements of the CAR creates a total LCC of $2,360 million. Only $518 million of this is the cost generated by the new vehicles and structure. Therefore for about a 22% increase in cost, the Marine Corps achieves a 32% force reduction (this reduction is the lost infantry structure) with an expected increase in combat power.

Yet, the fielding cost is significant at over $200 million. On the other hand, when the current three-battalion infantry regiment LCC for twenty years is developed the same way as was done in this analysis it has a total cost of $2,042 million. This demonstrates that the CAR(LAV) is only 13% more expensive than the current non-mechanized infantry operational units. A comparison of the CAR(LAV) to the original LAI battalion (with its 149 LAV's) whose similar cost is $582 million shows the CAR(LAV) to be almost four times as expensive.

B. AAV BASED CAR COSTS

The CAR(AAV) was not originally considered in the CAR conception. It was not until "From the Sea" was published that Marine planners began to seriously consider building the CAR around the AAV. The AAV was previously dismissed because of it's age, excepted higher operating cost, and slower overland speed, which reduced it's ability to function with the M1A1 tank. "From the Sea" emphasized expeditionary forces and crisis response, making it practical to consider using AAV's or even AAAV's to support the new concepts. The AAV amphibious capability gives it great flexibility in these types of environments. Another strength of the AAV is its larger troop capacity which would require half the vehicles when compared to an CAR(LAV). In the CAR(AAV), only two company sized AAV units would be required to tactically lift the CAR's infantry assets. This boils down to forty-seven AAVs per infantry battalion or ninety-four AAVs per CAR regiment. The present Marine Corps fleet of over 1200 AAVs has sufficient numbers of AAVs available so that a new production line would not have to be opened.

1. CAR(AAV) Vehicle Fielding Cost

Although new vehicles would not have to be purchased, the fielding of the AAVs would incur some cost. The ninety-four AAVs per regiment or 188 AAVs for two regiments are not currently in a fully operational condition. The total of 188 vehicles are in various states of repair at the two Marine Corps Logistics Bases located at Albany, Georgia and Barstow, California. These vehicles are not part of the War Reserve but act as the maintenance buffer stock that allow AAVs in the FMF to be cycled through depot level maintenance without degrading the active forces. Here the term buffer stock means that these AAVs are either on the maintenance line or in holding lots and provide for a constant exchange of upgraded or repaired vehicles with those coming from FMF units. This also means that some of the total 188 vehicles could be somewhere in transit which actually distorts the number slightly. The decision to use these vehicles in fielding the two CARs would have to be tempered with the realization that almost a full battalions worth of AAVs could be unavailable due to maintenance rotation (if the program continues to receive annual funding and is continued).

With that understanding, this thesis will assume for cost purposes that this decision has been made and all the vehicles will be upgraded to combat status. The AAVs at both Logistics Bases are repaired through a program called IROAN (Inspect, Repair Only as Necessary) and the average per vehicle cost has been determined for FY93 to be $79,784 at Albany and $96,401 at

Barstow. These costs fluctuate with the nation's economy and are only fixed annually. Additionally, there are approximately eighty-six AAV's at Albany and eighty-four at Barstow awaiting repairs or delivery while the remaining balance of vehicle is in transit. For those additional 18 vehicles it will be assumed that nine go to each site. This provides the following fielding cost information.

Location	Vehicle Quantity	Repair Cost	Total Cost
Albany	95	79,784	7,579,480
Barstow	93	96,401	8,965,293
			$ 16,544,293

This would be the cost to field two complete CAR(AAV)s but since this analysis is dealing with only the cost of one CAR's operations, different mixtures for AAV repair location could be conceived. This thesis will only consider the most expensive fielding cost of all ninety-four AAV's being repaired at Barstow for a total cost of $9,061,694. This is compared to the acquisition cost of $179.2 million for one CAR(LAV)'s vehicles.

2. CAR(AAV) Equipment Cost

Each Marine will be assigned an M16A2 which generates a personnel weapons cost of $250,263. The next step is to calculate the 782 gear cost for individual equipment. This value is $306,072 which combines with the individual weapons cost to give a total individual equipment cost of $556,335 for the CAR(AAV) required crews and mechanics.

Organization equipment cost will be allocated just of was done for the LAV's except in the CAR(AAV) the AAV is considered the main cost driver. Again the cost will be extracted from the cost factors manual with the allocation factor being created based on the current 184 AAV's in an Amphibious Assault Battalion. This creates an organization equipment overhead factor of $328,118 per vehicle, which when multiplied by the ninety-four AAV's in the CAR produces a value of $30,843,092 worth of equipment associated directly to the AAV's in the CAR. This generates an initial fielding cost for the CAR(AAV) of approximately $39.9 million as compared to the CAR(LAV) at 223.3 million. If the AAAV is used the CAR(AAAV) fielding cost is at least $265 million.

3. CAR(AAV) Personnel Cost

Life cycle lost calculation begin with the CAR(AAV's) personnel cost. This section will only consider the cost of the Marines required to operate and maintain the AAVs in the two companies of the CAR. The following table shows the vehicle mix by Company and Regiment, with crews and maintenance personnel.

Vehicle	Qty per Company	Crew per Vehicle	Total per Company	Total per Regiment
AAV(P)	43	3	129	258
AAV(C)	2	3	6	12
AAV(R)	2	5	10	20
				290

The AAV(R) crewmen are both mechanics and operators whom act as a Recovery team. In addition their are normally another nineteen mechanics per company in four maintenance teams for a total of 164 additional AAV specific personnel per CAR Infantry Battalion. Presently, no size has been determined for a regimental H&S Company maintenance section but this thesis will assume that it is the same size as the CAR(LAV)'s and will used twenty-three mechanics, bringing the total personnel count to 351 Marines. Here again it will be assumed that they will all be enlisted Marines for cost purposes, which results in a personnel cost of $9,750,078. The assumption of all enlisted Marines is made because the AAV's will be integrated into the infantry battalion, (vice organized as separate companies in the CAR) whose officers will have responsibility for command and maintenance of the vehicles.

4. CAR(AAV) Maintenance Cost

The current AAV battalions use a planning factor of $160 per hour per vehicle to estimate organizational maintenance costs. This is based on similar annual operating hours to the 250 hours used in this calculation . The result is that an estimated $3,760,000 will be spent annually on AAV maintenance in a CAR(AAV). The individual equipment upkeep cost is calculated based on 351 Marines at $519 each. The total estimated upkeep cost is $182,169.

The most accurate 1st FSSG planning factors exist for the AAV because it has the most usage data. In the AAV case a third and fourth echelon monthly maintenance factor of $2,092 is used, and for SECREPs a monthly factor of $1,229 is used. When applied to the ninety-four AAVs of the CAR over twelve months, this results in costs of $2,359,776 for third and fourth echelon maintenance and $1,386,312 for SECREPs. This produces twenty year costs of $47.2 million and $27.7 million respectively. These factors also reflect the higher cost of operation of tracked vehicles compared to wheeled vehicles, which is not clearly seen at the organizational level.

5. CAR(AAV) Ammunition Usage Cost

Here again the ammunition calculation include the values for either a .50 caliber machine gun or 30 mm guns to help compare the costs. One assumption is that all the required AAV(P) are equipped with the upgunned weapons station. First the constant costs are presented.

	Type	Quantity		Cost
M16A2	5.56 mm Ball	31,239		6,873
	Blank	70,200		8,424
7.62	Blank	32,000		8,640
	4 in 1	38,400		25,728
			TOTAL	$ 49,665

The 7.62 mm ammunition supports the AAV(R) on AAV(C) vehicles .

Next the assumption that all AAV(P)'s have the upgunned weapons station:

	Type	Quantity	Cost
.50 cal	4 in 1	129,000	188,340
40 mm	HE-DP	16,512	259,569
	TP	33,024	419,075
		AAV(P) Specific Cost	866,984
		Constant Cost	49,665
		TOTAL	$916,649

The other possibility is that each AAV(P) receives a 30 mm cannon during a block upgrade program or that AAAV's mounting 30 mm cannons are used.

Type	Quantity	Cost
30 mm	86,000	1,806,000
	Constant Cost	49,665
	TOTAL	$1,855,665

Since no ground based 30 mm gun exists, calculations were made assuming that allocation and use rates would be the same as those for the 25 mm gun. Additionally, the price per round of $21 plans for the round to be purchased in similar quantities as 25 mm ammunition.

6. CAR(AAV) Life Cycle Cost Summary

For the LCC development the author uses the ammunition factor based on a 30 mm weapon station.

Total Personnel Cost	9,750,078
Vehicle Maintenance Cost	3,760,000
Individual Equipment Cost	182,169
Annual Ammunition Cost	1,855,665

Annual Estimated Operation Cost (FY 93) $15,547,912

Over twenty years the LCC is $310 million to operate the CAR(AAV) vehicles. When combined with the cost of the existing CAR units the total LCC is $2,244 million of which approximately $402 million is new cost burden. With the CAR(AAV), the Marines achieve the same 32% force reduction in infantry, but only increase cost by 15%. Additionally, the cost of the CAR(AAV) is approximately 5% less expensive over a twenty year period. The fielding cost is much less expensive than the CAR(LAV) alternative but the AAV is nearing the end of it's service life and will require replacement or major upgrading to allow it to work with the M1A1. The replacement option, the AAAV, is discussed in the next section.

C. AAAV

Much has been discussed within Marine Corps circles about the AAV replacement vehicle, the AAAV. When fielded sometime after 2005, it will provide new options for Marine Corps tactical planners. Its high speeds and improved armament will create a powerful complimenting armored vehicle for the Marine infantry and tanks. With the exception of the current M2 Bradley in use with the Army, it will be the only other armored vehicle capable of keeping pace with the M1A1 tank. Yet with all the improved capability its price tag may prevent it from being obtained in sufficient quantities to perform any task other than the over the horizon (OTH) amphibious assault. This type of assault makes the defense of possible landing sites much more difficult because it increases the uncertainty of the specific site. The unit cost estimate of between $2.5 and $3 million appears to be prohibitive when trying to replace the current 1200 vehicle AAV fleet. Yet, because of it's compatibility with the M1A1, when the AAAV acts in the APC role, it has been considered for the CAR of the future.

1. AAAV Compatibility with Current Forces

A CAR(AAAV) would easily be transitioned, from a CAR(AAV) whose crews would already be familiar with tracked vehicle operation. It is logical to expect for mechanics and crewmen assigned to CAR's to also be assigned to Amphibious Assault Battalions and that they would have to receive all AAAV training. The decision to place AAAV's in all the previous units where the AAV is currently or could be boils down to two issues when discussing the CAR. First, if the CAR is to be a follow-on element of the MAGTF, does it need the high water speed capability of the AAAV or just an APC that is compatible with the M1A1 tank? It had been alluded to in Chapter II that the CAR's lift requirement would prevent it from filling most roles during the initial amphibious assault. Therefore the CAR's vehicles might be used in the breakthrough and exploitation phase of combat operations where the primary requirement is high overland speed and firepower. With this line of thinking, high water speeds are a wasted luxury that may not be required or affordable. Yet, to maintain the expeditionary emphasis of the Marine Corps units, an amphibious capability must be retained.

One way that a CAR could be lifted as an assault echelon force is if the amphibious shipping is transferred from on fleet to another (ie., Pacific fleet to Atlantic fleet). This would provide the required shipping assets to move the CAR. One side effect of this idea is, if the Marine Corps does need two CARs can one be designed for the follow-on echelon role? With this concept, theoretically one CAR would be built around AAVs or AAAVs while the follow-on echelon CAR would have LAVs. This could solve many of the problems associated with the CAR concept.

2. Discussion of AAAV Procurement Cost

The second issue confronting the CAR(AAAV) is the cost. The procurement cost of the AAAV is two to three times that of LAV which is already capable of keeping pace with the M1A1 under most conditions. The cost of crews and mechanics (which in numbers are planned to be roughly the same as current requirements) should not be expected to change much from that projected for a CAR(AAV), so in this area at least the AAAV doesn't cost any more than what is presently available. In the area of organizational equipment no real assumptions can be made. Surely some of the cost associated with the Assault Amphibian Battalion's organizational equipment will be the same regardless of the vehicle. How much new equipment cost is generated depends on how compatible the AAAV is with the AAVs maintenance support equipment. This could generate some significant new costs. Here the question of how much those increases in equipment and maintenance cost are must be evaluated. Some estimates place the twenty year life cycle cost for a fleet of AAAV's to be over twice the cost of the present AAV's and similar to a fleet of LAV's. The LAV fleet has similar cost because of the requirement to field twice the number of vehicles to do the same mission. Additionally, if the cost of additional Navy shipping, which would be required to transport the LAVs, is included, the LAV's become more expensive.

D. SUMMARY

This chapter has developed the annual expected operating cost for both CAR(LAV) and CAR(AAV). It has also introduced the AAAV and discussed in general terms the possible cost associated with it as a future alternative vehicle. For comparison purposes the following table is provided:

	Vehicle Quantity	20 Yr Life Cycle Cost(millions)
Current Infantry Regiment	Utility vehicles only	2,042
Current LAI Battalion	149 LAV's	582
CAR(LAV)	231 LAV's	2,360
CAR(AAV)	94 AAV's	2,244

None of the above stated cost include the acquisition cost or the fielding cost of the vehicles. A detailed breakdown of this chart is provided in the appendix. The CAR concept attempts to replace manpower with technology and thus retains the fighting capability of the Marine Division. The down side to this is that for a 32% force reduction, operating costs increase by about 10%.

One important issue pointed out by this analysis is that despite the increased number of vehicles required for the CAR(LAV), annual operating cost is not less expensive than the CAR(AAV). This is surprising because it is generally excepted that wheeled vehicles are between two and three times less expensive to operate when comparing fleets of equal size. It can be assumed that the ninety-four AAV's are below the breakpoint where there operations cost would exceed that of the 231 LAV's. Another contributing factor to this could be that the maintenance planning factors for either LAV's of AAV's are not accurate. When acquisition costs are factored in the CAR(AAV) is the less expensive alternative, at least in the short term. In the long term, the AAV is nearing the end of it's useful service life while the LAV is just beginning. The requirement to either upgrade or replace the AAV with AAAV's creates tremendous costs.

The issue of upgrading the AAV fleet or at least a portion of it is been explored in some detail in conjunction with the AAAV program. The idea of replacing the engine, suspension, hull, and weapons systems has been discussed as a lower cost alternative to the AAAV. These changes to the AAV would give it road characteristics similar to the M1A1, better survivability with improved armor for the hull, and firepower capable of defeating all known Soviet type threats with a 30 mm gun. If the cost of these upgrades is less than the over $170 million acquisition cost for the LAVs this is an option worthy of further evaluation prior to any CAR fielding plans being implemented. One source estimates that the cost of a stabilized 30 mm weapon turret might be as low as $50,000 and places an estimate for the upgraded suspension to be about $22,000 (CNA 88-166, 1988, p.11).

V. CAPABILITY COMPARISON

A. INTRODUCTION

This chapter will deal with the issue of what capabilities the CAR would provide the MAGTF commander. Many analysis have been performed dealing with only one aspect of an issue and often this is the cost or economic aspect of that issue. Cost is only one aspect of any decision making process. Very often cost is the only aspect thoroughly evaluated by decision makers which can result in missed opportunities or less than optimal decisions. The goal of this chapter is to provide the broader view of issues related to the CAR. The previous chapter provides decision makers with a baseline cost estimate and this chapter will provide a baseline evaluation for CAR capabilities, thus providing more information for Marine decision makers.

The goal of the CAR, as stated before, was to provide additional capabilities to the smaller Marine Division dictated by the force reduction. Specifically, the CAR was intended to increase both the tactical mobility and available firepower of the division's infantry. The concepts of both mobility and firepower will be explained and discussed in the appropriate following sections but can safely be assumed that both CAR(LAV) and CAR(AAV) would achieve some increase over the current divisional capability. It is difficult to place a dollar amount of the increment of additional capability provided by the CAR. Dollars buy equipment and equipment provides capability so the comparisons of this chapter will be of the capabilities of the CAR(LAV) and CAR(AAV) or more specifically, a comparison of LAVs to AAVs with some discussion of the AAAV. To ensure consistency with these comparisons, a single source for the base values has been reports provided by the Center for Naval Analysis (CNA). CNA has conducted detailed reviews for the Marine Corps of both vehicles, particularly in the Cost and Operational Effectiveness Analysis (COEA) and Performance analysis in the list of references. As was stated in Chapter I, much of the CNA material is contained in classified reports and it was the author's goal to avoid using any classified data. Therefore, only sections from the reports that were unclassified have been applied during this analysis and a simple comparison scale developed to relate the information.

1. Rating Scale

The comparison rating has been broken into five groups or categories: Low (L), Below Average (BA), Average (A), Above Average (AA), High (H). These ratings are designed to give the reader a perspective of capabilities discussed so that mentally, a general value can be arrived at. This scale provides a general ranking for the vehicle's characteristics and how well it fits the requirements of that characteristic. In this analysis, low will be defined as a failure to meet a minimum level of capability under most conditions, below average is failure to meet the minimum level of requirements under some conditions, average meets all required minimum capabilities, above average exceeds some capabilities in some conditions, and high exceeds all requirements in all conditions. Use of this rating system allows the reader to weigh the value of that specific vehicle in a general performance characteristic.

In all the areas where the High/Low scale is used a standard was developed based on a sample data set's mean. Three CNA reports (CNA 87-251, CNA 92-42, and CNA 93-138) were used as the source for the data sample. The mean or average of the sample provided the standard for the average (A) value. Then the sample data points were divided into the five groups used in the High/Low scale. In all the cases except the Vehicle Cone Index (VCI) measurement, used in the mobility analysis, the LAV was the only wheeled vehicle in the data set. This distorts the final evaluation to some degree.

2. Compatibility with Amphibious Capabilities

First, a general broad evaluation of the CAR's impact on the division will set the stage. The present MEF-sized MAGTF can transport one regiment by helicopter, one regiment by AAV, and the third regiment usually has to walk or sometimes rides in five-ton trucks. The availability of trucking is dependent on the logistic requirements of the force and this creates a very high demand for trucks on a modern battle field. During the Persian Gulf War there simply wasn't enough trucking available and it became evident why World War II leaders described the five-ton truck as a key to the U.S. Army's success. The CAR solves the problem of tactically moving the third regiment on the battlefield by providing additional armored vehicles.

When conducting an amphibious assault, the rapid build-up of combat power ashore is critical to the success of the landing. Presently, U.S. Navy shipping allows for two regimental sized MEB's to be transported to the battle area. Normally, the two MEBs have the capability to land one battalion each in AAVs, but first for purposes of this discussion a division sized MAGTF or MEF will be used. This allows for comparisons at the divisions maximum potential. Using this line of comparison the division would be able to land three battalions of AAV mounted infantry in a single assault wave. If shipping was available, a division equipped with a CAR(AAV) could land five infantry battalions in a single wave. Additionally, a division equipped with AAAV's and LCAC's (Landing Craft Air Cushion) could land the force from over the horizon keeping the ships out of range of direct fire weapons. Yet, the ability to transport a complete division is currently questionable, because of the limited amphibious shipping.

Second, more realistically the initial size of the surface assault force will not change with the fielding of any CAR. With this in mind the CAR now becomes a follow-on echelon organization, not available to GCE commanders until approximately ten days after a beachhead has been established. Under this scenario the GCE commander has three less infantry battalions available to hold his tactical position until the CAR could be offloaded. Even if the CAR's infantry was deployed in advance of its vehicles, the GCE would have less initial combat power because the two CAR infantry battalions are only about 75% of the size of current battalions. From this perspective the CAR fails to add any capability to the GCE until ten days after the opposed landing. This presents a very negative picture of the CAR's impact on the division but this should be tempered with the understanding that the negative impact is only felt during an opposed amphibious assault, which has not been conducted since the 1950s. Looking at recent military actions (Panama, Desert Storm), there has been sufficient time to build up a military force (often with the assistance of a host nation). The rest of this chapter will discuss specific capabilities of CAR vehicles. The discussions will begin with mobility, the primarily concern of the CAR developers.

B. MOBILITY COMPARISON

The primary goal of the CAR concept was to increase the tactical mobility of the GCE. After the Persian Gulf War it became evident to the Marines that on modern battlefield, walking to the battle area was unacceptable. Successful movement in a modern battle area requires that ground units be able to rapidly move over vast distances to take advantage of available opportunities or to economize the force. The CAR solves this problem by mounting troops in an armored vehicle.

Measuring mobility or the improvement in mobility is a difficult task because most definitions of mobility are very arbitrary. Simply speaking, mobility is being movable on the battlefield which equates to the ability of troops and equipment to be moved. This is a very simple explanation of tactical mobility and therefore any increase in that ability to move is an increase level of mobility. It can safely be assumed that providing more infantry troops with tactical vehicles increases the mobility of the overall division in most situations (ie., swamps, jungles). So in the broad perspective the CAR, regardless of which vehicle is used, increases the infantry's tactical mobility.

A more precise definition of vehicle mobility involves the interaction of the vehicle with the terrain or ground over which it moves (CNA 90-138, 1990, p.2). Several characteristics of the vehicle influence on it's ability to move over the ground. Some of these characteristics are track width and length, number of powered wheels, ground clearance, horsepower, weight, horsepower to weight ratio and size of the wheels. From this short list it is easy to understand why it is difficult to precisely measure mobility. Another, aspect of mobility is terrain, also having many factors which effect it including soil type and condition, vegetation, topographic relief, moisture in soil, soil's resistance to pressure, and climate. Models exist which try to represent all the interactions of these factors and some conclusions have been developed. First, the higher the horsepower to weight ratio the better the vehicles mobility in most conditions (CNA 182, 1991, p.16). Second, the lower the ground pressure the better the traction and thus mobility (CNA 87-251,1988, p.10). This analysis will specifically use the Horsepower per Ton ratio, Vehicle Cone Index values, and Drawbar Pull strengths to make its evaluation.

1. Horsepower per Ton Ratio Comparison

The first mobility measurement to be considered will be the Horsepower per Ton ratio. This is simply the available horsepower divided by the vehicles combat weight. To allow a simple comparison the following table is provided:

Vehicle	Hp/Ton	Combat weight(Tons)	HP/Ton Rating
LAV	19	14	Below Average
AAV	15.2	26	Low
AAAV	31	32	High
M2 Bradley	18.2	33	Below Average

Here the standard value from the data set calculations was 22.7 Hp/Tons and the AAV had the lowest Hp/Ton ratio of the sample data set.

The LAV-25 is used as a representative vehicle for the LAV(P) because no real data is available for the LAV(P). This initial comparison put the AAV last because of it's low horsepower to weight ratio. This is not surprising since the LAV-25, although having less horsepower, also weighs half as much. This comparison also assumes only 1000 horsepower is available from the AAAV 2600 horsepower engine. (This is assumed based on the AAAV not operating the water jets while on land.)

Even if less than half of the engines horsepower is available for land movement the AAAV's Hp/Ton ratio is well above the next best vehicle. Here the M2 Bradley is shown to allow a comparison to be made of an APC currently operating with the M1A1 tanks fielded by the U.S. Army.

2. Vehicle Cone Index (VCI) Comparison

One useful tool for comparison is Vehicle Cone Index (VCI). This is a measure of the vehicles ability to make a single pass over level ground. The VCI can be compared to the Relative Cone Index (RCI) of the soil. If the VCI is higher than the RCI the vehicle is in a no go situation. Therefore the lower VCI the more mobile the vehicle over the wider variety of terrain (CNA 90-138, 1990, p.2). RCI is a measurement of the shearing resistance of a type of soil.

The vehicle's VCI is dependent on the soil conditions and vehicle weight and therefore differs with the various soil conditions. The standard value used here for the VCI comparison is 33, which was created from a sample of both wheeled and tracked vehicles. It is important to note here that wheeled vehicles normally have higher VCIs than tracked vehicles because the tires produce a smaller contact area with the ground. The follow table relates the vehicles VCI in various terrain conditions.

	Hard surface(RCI=300)	Mud(RCI=50)	Swamp(RCI=50)	Sand(RCI=50)
LAV	31.7	31.7	61.4	19.2
AAV	15.6	15.6	31.2	0.0
AAAV	20.3	20.3	34.3	0.0
M2	18.4	18.4	36.6	0.0

The VCI's can be averaged to develop the comparison rating below:

	AVG VCI	RATING
LAV	36	Average
AAV	15.6	Above Average
AAAV	18.7	Above Average
M2	18.4	Above Average

This comparison reflects the better mobility of tracked vehicles and gives the AAV7 a definite advantage when compared to the LAV.

3. Drawbar Pull Comparison

Another simple measure of mobility is drawbar pull which is the reserve power left in a vehicle after it uses the power required to move itself. To develop drawbar pull simply subtract the amount of force the soil can withstand before giving way from the resistance of the soil to vehicle motion. (CNA 90-138, 1990, p.2). The next table compares the drawbar pull in pounds of the possible CAR vehicle options.

	Hard Surface	Mud	Swamp	Sand	Dry Snow
LAV	16,759	11,856	-3,299	3,975	7,598
AAV	35,037	31,792	32,198	26,553	25,224
AAAV	49,096	43,650	42,080	37,098	36,142
M2	43,791	39,287	34,223	39,287	31,272

Here again we average the available drawbar pull to develop the comparison table.

	AVG DRAWBAR	RATING
LAV	7,377	Low
AAV	30,161	Average
AAAV	41,613	Above Average
M2	37,572	Above Average

With this comparison we see that the LAV is in a "no go" situation when pulling loads in swamp conditions. Additionally, it should come as no surprise that the highest horsepower vehicle, the AAAV does best in drawbar pull comparison.

4. Summary of Mobility Comparison

Combining the results of all three comparison are in the following table.

	HP/TON	VCI	DRAWBAR PULL
LAV	Below Average	Average	Low
AAV	Low	Above Average	Above Average
AAAV	High	Above Average	Above Average

In all three categories the AAAV does better than the minimum acceptable established standard of performance. Comparing the LAV to the AAV is a closer call but the tracked AAV dominates the LAV in the mobility characteristics. One area not evaluated above is land speed and in this area the wheeled LAV always does better than tracked vehicles on improved roads.

So far the discussion has centered only on tactical land mobility. Yet, the Marine Corps must also consider the ship to shore mobility of the vehicles and the transportability of those vehicles in and around the theater of operation.

These issues will be briefly discussed next.

The LAV is the only vehicle under consideration that is liftable by the CH53E helicopter. Granted the lift capability is only one LAV per helicopter but this still provides the GCE commander an additional raid or reconnaissance option. The LAV and AAV are both airliftable, but in limited quantities. The following table presents accepted planning factors for the most common types of cargo aircraft.

	C130	C141	C5
LAVs per A/C	1	3	9
AAVs per A/C	0	0	5

This provides an added degree of flexibility for both in theater transfers and allow the vehicle to get on the scene quickly if a friendly airfield is available.

An area of vital importance to expeditionary operations is ship to shore movement. In this area the AAV and AAAV have the upper edge. Having the capability to launch itself then swim 4000 yards to the beach allows the amphibious vehicle to more rapidly build up combat power ashore. The AAAV is designed to be launched from up to twenty miles off the beach thus creating more options for the battlefield commander. The LAV is compatible with all current Navy landing craft and can be carried in the following numbers.

	LCM 8	LCU	LCAC
LAVs per craft	2	7	5
AAVs per craft	1	4	3

The LCAC give the LAV an Over the Horizon launch capability similar to that of the AAAV. Although more LAVs than AAVs can be carried by the LCAC, the development of combat power ashore is still slower as the CAR's LAVs would have the nine man squad. One LCAC would land forty-four combat troops and their LAV vehicles as compared to fifty-four troops and their AAVs, if the vehicles did not swim ashore. Another limiting factor in ship to shore movement is the availability of LCAC. Currently, a MEB normally plans on having twenty-four LCACs for ship to shore movement. Additional LCACs would be required to lift the LAVs to the beach and this would have the domino effect of requiring additional shipping.

To sum up the mobility issue, either CAR increases the mobility of the infantry over what is presently available. In the urban environment the LAV's high road speed gives it an advantage, yet in the threat description from Chapter I this is not the anticipated engagement scenario. In the off road environment the tracked options have better mobility. Additionally the amphibious capability of the AAV and the AAAV provide for a rapid build up of combat power in a hostile situation or a situation requiring entry at a location other than an improved facility. This more adequately fills the expeditionary role of the Marine Corps operations. It also provides the flexibility of a ship born force capable of forward presence without actual insertion into a country. Yet when that insertion is directed by the President it can happen quickly without delay based on landing craft availability. For these reasons the CAR(AAV) is the better more flexible mobility enhancement option.

C. FIREPOWER COMPARISON

The second goal of CAR developers was to increase firepower over the current levels in the division. The CAR in any form has the potential to do this. The measure of firepower can be evaluated in many ways. A general broad stroke is to simply count available weapons. Under the current structure an infantry regiment has the following organic weapons in addition to the infantry's individual weapons (M16, M9, Squad Automatic Weapon). It should be noted that these weapon quantities are based on a Infantry Regiment with three Battalions of three Rifle Companies using a twelve man squad and one

Weapons Company.

Weapon	Qty	Density
SMAW 83 mm	18	6 per Weapons Plt.
M60E2 7.62 mm	29	6 per Weapons Plt.
M2 .50 caliber	6	6 per Weapons Co.
MK19 40 mm	6	6 per Weapons Co.
Dragon	24	24 per Weapons Co.
60 mm Mortar	9	3 per Weapons Plt.
81 mm Mortar	8	8 per Weapons Co.
TOW	24	All in Reg. Anti tank Plt.

Most of the heavy crew served weapons are grouped into either weapons platoons or weapons companies, and are tasked out as the situation demands. The rest of the weapons in the Marine Corps inventory are tasked to support infantry units as necessary. Although there would be fewer M16A2s available in the CAR (because of its reduced size) the practice of tasking heavy and crew served weapon systems to units as required will not change. Additionally, the basic mixture of weapons available to the infantry will not change. The change in infantry firepower with the CAR will be in the vehicle-mounted weapons. In the CAR(LAV) the infantry will have direct control of the 25 mm gun mounted on the organic LAV 25s. The LAV 25s would provide forty-two additional weapons capable of defeating all known soft or thin-skinned armored vehicles. (The thin-skinned armored vehicle is defined here as a Soviet BMP equivalent.) Additionally, these LAV's will provide forty-two more 7.62 mm machine guns that can be used to defeat infantry and unarmored vehicles. If the Marine Corps should buy the LAV(P) with a turret configuration mounting the .50 caliber machine guns, then an additional seventy-eight weapons capable of defeating thin-skinned armored vehicles are provided to the Ground Combat Element (GCE). This would be a significant increase over the current firepower in an infantry regiment which has eighteen .50 caliber machine guns and eighteen

MK 19s. The weapons on the LAVs provide an almost 200% increase in firepower for the regiment.

The same basic results occur in the CAR(AAV). The present AAV with the upgunned weapons turret mounts a .50 caliber machine gun and a 40 mm automatic grenade launcher, both of which can defeat thin-skinned armored vehicles. Therefore, the CAR(AAV)'s APCs provide eighty-six additional anti-armor weapons able to defeat thin-skinned targets. In the case where the AAV's are upgraded with 30 mm automatic cannons then the ability of the CAR(AAV) to defeat thin-skinned vehicles is still improved through increased effective range and greater potential to kill the target. This general comparison show that both CAR options increase the infantry's ability to counter the thin-skinned armor threat. The following table shows the number of additional direct fire guns available in a CAR not counting the TOW assets to defeat thin-skinned armor threats.

	Guns
Current Infantry Regiment of 3 Battalions	36
CAR (LAV)	
Infantry (2 Battalions)	24
LAV 25	42
LAV (P)	78
CAR (AAV)	
Infantry (2 Battalions)	24
AAV (P)	86

1. Comparison Using Probability of Kill Values

A more refined measurement of firepower involves the development of Probability of Kill or PK values. Here, firepower is defined as the effect of a weapon against a threat target (CNA,88-248, 1989, p.13). Under this evaluation of firepower, the analysts are able to measure the lethality of the weapon system. The development of PKs has been extensively modeled by operations researchers, but in almost all cases the results are classified. This discussion will center on how a PK is developed and then scale the weapon's effectiveness using the High/Low comparison.

A PK factor is a measure of lethality that depends on what type of weapon is used, what the target is, what the target is doing, and what the firing system is doing. First, the type of weapon determines the penetration of the munition involved, the type of target that can effectively be engaged (ie., A 7.62 mm machine gun can effectively engage troops and unarmored vehicles but not APCs. A simple rule of thumb with direct fire weapons is: the larger the projectile the larger the target it can be used against.), the type of projectile used, and the accuracy of the weapon. In the LAV 25 case, the weapon is a direct fire 25 mm automatic cannon capable of firing armor piercing rounds. The .50 caliber machine gun mounted on a LAV(P) is much the same as the 25 mm except with less range, less penetrating power, and less accuracy due to it being unstabilized. The 30 mm of the upgraded AAV or AAAV is a longer range weapon with better penetrating power.

The second aspect of the lethality factor is the target. In this analysis all targets will be BMP equivalents. The BMP is a lightly armored soviet APC used throughout the world. The targets will be considered to have only two postures for this evaluation. The targets will be either "exposed" or under cover in a defilade position. This represents the two extremes of vehicle vulnerability with exposed placing the vehicle in the most vulnerable situation. Another aspect is the angle at which the target presents itself to the firing weapon. Here only a full flanking shot will be considered. Under this situation the vehicle presents the largest target area for the firing weapons gunner.

Next, the activity of the firing weapon system must be evaluated. The weapon system can be fired from a stationary protected position or while on the move. This impacts on the accuracy of the firing weapon and therefore its ability to hit the target. Other factors that effect the weapons accuracy are its crew, the type of sights on the weapon, and how the weapon is mounted on the firing platform. The height of the vehicle affects the gun's stability which has an impact on accuracy. Shorter vehicles tend to be more accurate firing platforms (CNA 87-251, 1988, p.25). In this analysis the LAV and AAV weapons will be considered to be firing from a stationary protected position. The LAV(P) weapon station is approximately 7.2 feet above the ground and the AAV(P)'s weapon station is 10.7 feet above the ground.

All of these issues combine to develop a PK for each weapon at different ranges in different postures. The actual PK is a product of the probability of the weapon hitting the target or Phit and(once the round hits the target) the probability of that hit being a kill, whether that be catastrophic, mobility, or firepower (Hartman OA 4654, 1992, p.136).

These conditions used in this analysis represent only one of many situations for the firing weapon to be in. The range will be divided into short (1000 meters or less) and long (2000 meters). With these criteria as a frame of reference, the following table provides for the probability of killing a target with either a .50 caliber or 30 mm gun firing a single shot. Additionally the PK value used has been aggregated over all range bands and postures.

	Exposed		Defilade	
	Short Range	Long Range	Short Range	Long Range
.50 Cal	Average	Below Average	Average	Low
30 mm	High	Above Average	Above Average	Average

When a five round burst is used:

	Exposed		Defilade	
	Short Range	Long Range	Short Range	Long Range
.50 Cal	Above Average	Below Average	Below Average	Low
30 mm	High	Above Average	High	Above Average

It should come as no surprise that the 30 mm gun is more effective in all categories of this comparison.

2. Stowed Kill Calculations

One further calculation that can be done is an estimate of "Stowed Kills". A vehicles stowed kill value is the number of targets that can be destroyed with the available ammunition on the vehicle. This can be multiplied against the PK value to approximate the number of BMP equivalent targets that can be killed when entering the battle. The following ammunition loads are assumed:

WEAPON	ROUNDS
.50 Cal	1200
25 mm	650
30 mm	375

With these values we can estimate the following "Stowed Kill" values when the target is exposed. In this case the PK used is an average over several ranges and postures to prevent the compromise of classified data.

WEAPON	STOWED KILLS
.50 Cal	1
25 mm	13
30 mm	7

A simple calculations done to relate these estimates to the vehicle based CAR's using the number of vehicles involved.

UNIT	WEAPON TYPE	WEAPON QUANTITY	TOTAL POSSIBLE STOWED KILLS
LAR Company	25 mm	14	182
CAR (LAV)	25 mm	42	546
	.50 Cal	78	78
CAR (AAV)	.50 Cal	86	86
CAR(AAAV)	30 mm	86	602

In the CAR(LAV) it is assumed that each LAV(P) is equipped with the proposed .50 caliber turret. The possible stowed kills combining the CAR(LAV)'s organic assets is 624 BMP equivalents. While the CAR(AAAV) or CAR(AAV) upgunned to a 30 mm weapon could be expected to kill 602 BMP equivalents. As a caveat, these values do not include the possible kills that could be achieved by the LAR company, tank battalion, and infantry antitank weapons. These calculations also do not consider the attrition of Marine forces from casualties inflicted by the enemy.

3. Summary of Firepower Comparison

The CAR(LAV) has the advantage of organic LAV 25s to increase its potential ability to kill enemy APCs. If the LAV(P) fails to receive the .50 caliber gun turret, the CAR(LAV) still has more potential ability to kill APCs, because of the organic LAV 25s, than the CAR(AAV) does using currently fielded equipment. One advantage of the CAR(AAV) not reflected here is the vehicle's existing .50 caliber gun which exists today to provide support for the infantry thus not requiring an upgrade. The current LAV(P) provides only a 7.62 mm machine gun.

It can safely be assumed from this analysis that the added weapons of either platform significantly increase the automatic weapons available to the GCE commander. Using the currently fieldable vehicle types, the CAR(LAV) has the advantage over the CAR(AAV) in the potential for killing thin-skinned armored vehicles. One question that should be considered here is whether the CAR's vehicles' role will be to act as APCs or IFVs. (That is Armored Personnel Carriers or Infantry Fighting Vehicles.)In the APC role, the infantry is the primary weapon used to defeat the enemy and is supported by the vehicle's weapons (CNA 88-248, 1989, p.12). If the CAR's vehicles are to be used as IFVs, the vehicles' weapons do the fighting and are supported by the infantry. In the LAV(P) and the AAV(P) case, it should be assumed that they will fill the APC role. This is not the obvious decision when evaluating the LAV 25 which has the capability to engage and defeat practically all known thin-skinned vehicles. In addition, the infantry on board is used to protect the vehicle or act as scouts. With this in mind, the LAV 25s of the CAR(LAV) may be used in roles other than direct support of the infantry. One example is using them as a screen for the rest of the force. This may result in their being geographically unable to support an infantry engagement and thus unable to apply their combat power to the infantry's mission. If this assumption is made, then the total possible "Stowed Kills" for CAR(LAV) do not change but the infantry may loose a valuable direct support weapon.

D. SURVIVABILITY COMPARISON

This issue is basically the opposition's view of lethality discussed in the previous sections. A vehicle's survivability primarily depends on its size and armored protection but also on the enemy's ability to effectively use his weapons against the vehicle. In discussing the enemy's ability to kill LAVs or AAVs, the enemy must do all the same things described in the firepower section. The factors that the United States forces can control are the vehicle's size, speed and armor. Increasing one often decreases another. For example, if new reactive armor is placed on a vehicle the vehicle size increases and speed decreases.

The analysis of survivability will primarily center on vehicle size and speed since armor characteristics are classified. The LAV is much smaller than the AAV. The LAV's main hull is just over six feet tall and twenty-one feet long. As the LAV exists today its road speed is in excess of sixty miles per hour. The

AAV is approximately eight and a half feet tall and twenty-six feet long. It is also more than twenty miles per hour slower than the LAV. Its larger size makes it easier to acquire by enemy gunners. To compensate, it also has increased armor protection. The AAV's slower speed makes it less capable of evading enemy gunners once it has been seen. The LAV, on the other hand, is fast and small, giving it better survivability under some conditions. To help understand this the following table provides a High/Low comparison of the chance of each vehicle being hit by either a Soviet type 14.5 mm machine gun or a Soviet 30 mm gun.

14.5 mm	Short Range		Long Range	
	Single shot	5 Round burst	Single shot	5 Round burst
LAV	Below Average	Average	Low	Low
AAV	Average	Above Average	Low	Low
30 mm				
LAV	Above Average	High	Average	Average
AAV	High	High	Above Average	Above Average

The AAAV could be expected to have similar characteristics to the AAV but with improved armor. With this simple comparison, the LAV appears to be more survivable. In this kind of analysis, it is difficult to measure the effect of better armor on survivability. Yet, if the AAV were upgraded with increased speed and armor, the choice would be more difficult. The current M2 Bradley, although large, is both fast and heavily armored, making it exceptionally survivable. These are the same traits that the AAAV would have, thereby making it the best choice for Marine operations, if it can be developed with the mobility, firepower, and survivability used here for a reasonable cost.

E. SUMMARY OF CHARACTERISTIC COMPARISON

In all three areas, the expected capability of the AAAV made it the vehicle of choice. When evaluating only currently available vehicles, the LAV appears to be the best choice for the CAR assuming that the CAR will not be used in an amphibious assault. This is based on on the LAV's high road speeds, excellent inherent firepower, and good survivability. Additionally, the LAV's relative youth when compared to the AAV provides a cost incentive in hopes of having lower long term cost. Yet, due to the nature of Marine Corps operations discussed in Chapter II, mobility must be the deciding or most heavily weighted area. For this reason, the AAV would be the vehicle of choice. The good cross-country terrain capability inherent to a tracked vehicle plus the AAV's ability to swim ashore are the reasons for decision. In both firepower and survivability, the AAV has sufficient abilities to sustain it until the AAAV is available. If these current abilities are deemed lacking, plans are available to upgrade the AAV to levels of performance equal to that of the LAV. Additionally, if these upgrades can be performed at less cost than the acquisition of the required LAVs, then savings to the Marine Corps can still be realized. Lastly, the AAV based CAR would provide a smooth platform to transition to the AAAV once it is operational.

VI. CONCLUSION

A. DISCUSSION

The previous chapters have discussed the cost and capabilities of the Combined Arms Regiment (CAR). The CAR concept was developed by the Force Structure Planning Group to prevent the Marine Corps from losing its combat effectiveness if the force reduction capped the Marine Corps strength at 159,00 Marines. The objective of this paper was to establish the twenty year life cycle cost of the CAR options. In support of this cost estimate, Chapter II explained how the Marine Corps envisioned its role in the Nation's defense. Once that role was established the CAR's fielding cost and Life Cycle Cost (LCC) over twenty years were estimated. A complete summary of these costs is found in the appendix. Last, this thesis examined the issue of what capabilities the CAR would bring to the Marine division. This analysis compared the various APC options being considered by Marine Corps planners, and presented some ideas about the AAAV as a future vehicle.

The Marine Corps, since inception, has placed its future on the concept of being the country's rapid response force, able to respond quickly to any world crisis. Marine forces will need to be both flexible and mobile to fulfill the expeditionary role envisioned. The heavy emphasis on expeditionary forces, designed to fit the crisis, requires Marine Corps units that can get to the crisis area aboard the available shipping and then, in most cases, move themselves from ship to shore without the aid of improved port facilities. This requires the use of amphibious vehicles or landing craft capable of a quick turn around to the ships for multiple loadings. Once ashore the force will have to move itself through a country which may have little infrastructure in the way of roads.

The CAR, whether based on LAVs or AAVs, doesn't enhance the rapid movement characteristic of Marine forces to a crisis, in that the additional vehicles require more time to prepare and embark for transport. The CAR as it was envisioned would not attach its companies out to other MAGTFs but would have artillery and engineer units attached to it as the core of an armored MAGTF. The building or "task organizing" of units to fit the specific task is a hallmark of the Marine Corps' rapid response and expeditionary capability. Over the last forty years, the Marines have refined the skills required to effectively task organize its units to a precise art, as demonstrated in Beirut and Grenada. The CAR's construction as a mechanized infantry regiment does not lend itself to being task organized into MAGTFs below the MEB level for two reasons. The first reason rests with the basic CAR concept, which would have the CAR fight as a whole unit with other assets supporting it rather than being broken into pieces to support other units. The second reason is that to realize the full benefit of mechanized forces they must be used as a team rather than separate elements. This makes transporting it a much bigger and slower logistics evolution. To rapidly move the CAR, its armored vehicles will need to be prepositioned on shipping or at least geographically in theater.

If the shipping is assumed to be available, then the issue for the CAR is at what point in time will it be committed to the crisis area. If the CAR is to be part of the assault or initial combat phases, then the AAAV or AAV based CAR is the only practical solution. This comes from the AAAVs' and AAVs' ability to move in the amphibious mode and rapidly build up combat power ashore . In the follow-on echelon phase, the LAV is the better choice. Using the CAR in the follow-on phase is also supported by the forecasted available shipping.

Further, no opposed amphibious assault against a major power has been conducted since the Korean War. With this understanding, the possible ten day wait for CAR's assets to arrive aboard MPF shipping should not be seen as a detriment to the CAR(LAV). The division will still retain the capability to land a regiment of Marines with the organic AAV or future AAAV assets in the Assault Amphibian Battalion. Once the beach head is established by these forces, a CAR(LAV) could be landed to exploit the inherent speed and firepower of the LAV.

The problem for a CAR(LAV) is that transporting its 231 vehicles would require the construction, leasing, or purchasing of additional shipping. The construction or modification of shipping are long term programs that would have to be started now to provide adequate shipping early in the next century. The leasing of suitable ships requires vessels to be under a nations flag that is supportive of the cause for which the ships would be used. In both situations the problem of actually loading the ships is generated when attempting to transport the CAR. Also the problem of offloading the LAVs in a country without suitable port facilities is still not completely solved without additionally U.S. Navy landing craft to support the leased or modified civilian shipping.

B. SUMMARY OF EFFORT

When evaluating the CAR options on purely cost considerations, the CAR(AAV) is the least expensive choice. Using the current AAV(P), which has double the troop capacity of the LAV(P), allows for some savings when evaluating the other areas of cost (ie., organizational maintenance). The AAV, which is more expensive to maintain on an individual bases is actually cheaper in this case because only about half the total number of vehicles (when compared to LAVs) are required to move the same number of Marines. This also applies to the maintenance costs where the low numbers allow the AAV to be maintained for less than the LAV. However, this maybe a short-sighted conclusion. The AAV is near the end of its service life. As the vehicle gets older it can be expected that maintenance costs will increase. The LAV, on the other hand, is basically brand new, and being wheeled could be expected to have lower unit maintenance costs than the AAV. Additionally, the fielding of more LAVs would increase the number of vehicles in the force, which could produce some small cost savings.

When evaluating the AAAV as an AAV replacement, the issue of CAR employment must be discussed. The AAAV should be an excellent weapon system for ship to shore movement. Additionally, it should have the compatibility required to work with the M1A1 tank. Primarily though, the AAAV's strength of high water speed can be most effectively utilized during the assault or initial phases of combat. If the CAR is to be used as part of the follow-on echelon, high water speed (which generates much of the AAAV costs) is not required. Once ashore, in the breakout phase, only the high land speed is critical. The CAR(LAV) would fulfill that requirement while a CAR(AAV) would require either the procurement of the AAAVs or substantial modification of the AAVs to achieve the same land speeds.

Lastly, when evaluating the other capabilities provided by the CAR's vehicles, the result again leans to the LAV. The AAV's performance in its current configuration exceeds that of the LAV only in the area of mobility. The capability of the AAV to swim gives it a truly expeditionary flavor not found in the LAV. Additionally, once ashore, the AAV provides more flexibility to the GCE commander. "In rough terrain, the LAV will be somewhat inferior to the tracked vehicle." (OH 6-6, 1985, p. H-2). Additionally, the LAV lacks some of cross-country capability of tracked vehicles. Yet, in other areas the LAV has superior performance to the current AAV. The CAR(LAV)'s organic firepower and survivability make it an excellent unit on the battlefield. One shortfall not examined in this thesis is the threat of enemy tank forces. The LAV realistically will not be able to successfully engage heavy armor forces, which it may face. As the number of enemy tanks increases, the need for a heavily armored CAR also increases. With the current composite armor the AAV may slightly more effective in this kind on combat environment.

Although not the focus of this research, the proposed AAAV is the only vehicle which completely fills every requirement of the CAR. It will have the expeditionary capability, inherent firepower, and survivability to handle the future threat that must be expected by the Marine Corps. The problem here is that the Marine's limited funding resources may prevent the AAAV from being procured in sufficient quantities to fill both the present AA Bns and two CARs. Yet, the limited resources may also prevent the CAR(LAV) from being fielded which is the next best alternative. The cost to procure the required LAVs and supporting shipping requirements may also be beyond the financial abilities of the Department of the Navy. The interim low cost alternative could be the CAR(AAV) with AAVs upgraded to extend the vehicles' life into the future and enhance its capabilities. This idea has some merit, and tests are already being conducted using an M2 Bradley type suspension on the AAV to increase its speed. Additionally, the 30 mm gun upgrade would be an extension of a weapon system already fielded on the LAV 25. These two upgrades would overcome the main shortcomings in the AAV and allow it to operate more easily with M1A1 tanks.

C. RECOMMENDATIONS

The initial line of planning within Marine Corps circles, on the CAR, is supported by this thesis. The CAR(LAV) is, with some exceptions, a cost effective solution to the problem of maintaining combat strength in a smaller force. It also provides a viable force option to increase the tactical mobility of Marine Corps ground forces. In two respects the CAR(LAV) must be reevaluated. First, the CAR(LAV) does not increase the Marine Corps' expeditionary capability since it must be used as a follow-on component of the force structure. If used as a breakout tool, the CAR(LAV) may not be heavy enough to defeat an enemy force with many tank assets. The days of massive Soviet armored forces may be gone, but many third world nations now have substantial tank forces.

This creates the second concern about the CAR(LAV). If its shortcomings prevent it from performing that breakout role, then a more heavily armored alternative should be evaluated. The current AAV used in the Persian Gulf War has been upgraded with composite armor, and the AAAV will also have improved armor, making them more capable in armored environment. The proposed AAAV, or the upgraded AAV, provides a practical solution to fill this requirement. Evaluation of the AAV may show it to be an effective low cost alternative to support the CAR for many years. If the required ninety-four AAVs can be fielded for around $200,000 each, then this option may fit the expected funding constraints. Since the possible upgrades to the AAV would be less costly than purchasing the required LAVs, and would fill all the requirements of the CAR, this alternative should be studied to determine its merits.

D. CONCLUSION

The CAR concept is a useful organization regardless of the size of the Marine Corps. The combination of tanks and mechanized infantry is a powerful force on any battlefield, capable of achieving great success. Unfortunately, the CAR's cost may prevent it from ever being fielded in each division. Even when considering a low cost CAR(AAV), the resulting increase to the operating budget of the Marine Corps may be beyond the available resources. Other factors may also contribute to the CAR's demise. Until additional shipping can be provided, there will be no clear alternative to transport any CAR to the crisis area. With the projected block retirement of many classes of amphibious ships in the late 1990s, no alternative exists to move the CAR as part of the assault echelon. One consideration might be to replace other equipment on board the ships with the CAR's vehicles. Yet, that might degrade the well rounded combat strength inherent to a MAGTF. Second, the Marine Corps has, over the years, refined its ability to task organize its units to fit the situation to an extremely high level of proficiency. To be truly flexible, this pattern of task organizing must be continued. At the MEF level, a Marine commander already has the prerequisite assets within a division to form a CAR type MAGTF if the situation warrants. The Marine commander could, if the situation warranted, cross attach his Tank Battalion to an infantry regiment already attached to the division's Assault Amphibian Battalion AAV assets. That being the case, the only benefits from a standing CAR are additional vehicles, providing all their capabilities, plus the formalized structure for training.

The proposed AAAV is the only vehicle that realistically will be able to conduct an opposed landing on the future battlefield. Yet, its high cost will prevent its procurement in numbers large enough to support both the current

AA Bns and the proposed CARs. The CAR(LAV) is a suitable option until considered in conjunction with the requirement to obtain more ships to transport it, which then makes this option to costly. This leaves the CAR(AAV) using upgraded AAVs as the best choice. Since it must be assumed that the CAR will only be a follow-on unit, the high water speed of the AAAV is not required. Additionally, as the AAVs are replaced with AAAVs, a large pool of parts and vehicles will be available for use in the CAR. This, coupled with the expected low cost to upgrade the AAV's suspension and onboard weapon system, make it the cost effective solution. What ever the results of the force restructuring, this thesis will provide one more resource to help base future related decisions.

APPENDIX A

GLOSSARY

The Marine Corps has shortened many of its commonly used terms into acronyms that the reader may not be familiar with. This section provides a list of all the common acronyms used in this thesis. Additionally, if the acronym is not self explanatory, a short description or definition is provided.

AA Bn - Assault Amphibian Battalion

AAV7 - Assault Amphibious Vehicle which is the amphibious Armored Personnel Carrier which is currently in service.

AAA - Advanced Amphibious Assault. The development program designed to replace the current AAV7.

ACE - Aviation Combat Element, task organized to perform mission.

AE - Assault Echelon

AFOE - Assault Follow-on Echelon

APC - Armored Personnel Carrier

CM - Corrective Maintenance

CE - Command Element, provides command and control for the organization

CSSE - Combat Service Support Element, task organized to perform mission

Dragon - Man portable wire guided anti tank missile. Found at the battalion level

FMF - Fleet Marine Force, deployable forces of the Marine Corps.

FY - Fiscal Year, For the Department of Defense this runs from October 1 to September 30.

GCE - Ground Combat Element, task organized to perform mission

H&S - Headquarters and Service company or battalion

LAV - Light Armored Vehicle, all the LAV family vehicles are either in service or in procurement except the Personnel variant.

LCC - Life Cycle Cost

MAGTF - Marine Air-Ground Task Force. A tailor made organization designed for rapid deployment by sea or air. It has an ACE, CE, CSSE, and a GCE.

MEB - Marine Expeditionary Brigade. Reinforced regimental size MAGTF.

MEF - Marine Expeditionary Force. Reinforced division size MAGTF.

MEU - Marine Expeditionary Unit. Reinforced battalion size MAGTF.

MK19 - The 40 mm automatic grenade launcher used at the battalion level.

MOS - Military Occupational Specialty

MPF - Maritime Preposition Force. Three squadrons of ships located around ready to respond to a crisis situation.

M9 - 9mm pistol currently used by officers.

M1A1 - The Main Battle Tank currently in service.

M16A2 - Assault rifle currently in service that uses a 5.56 mm round.

mm - millimeter. Normally used to reference ordnance sizes.

PM - Preventive Maintenance

OTH - Over the Horizon.

SAW - Squad Automatic Weapon, a 5.56 mm automatic weapon used at the fireteam level.

SECREP - Marine Corps maintenance term used to describe items like alternators that can be removed as a subassembly of a larger end item.

SMAW - Shoulder Launched Multipurpose Weapon, an 83 mm rocket designed to reduce fortified positions.

TOW - Tube Launched, Optically tracked, Wire guided anti tank missile.

APPENDIX B

AMMUNITION COST AND USAGE FACTORS

TYPE		COST PER ROUND	USAGE RATE PER WEAPON
5.56 MM	BALL	0.22	190
	BLANK	0.12	400
7.62 MM	BLANK	0.27	4000
	4 IN 1	0.64	4800
9 MM	BALL	0.13	100
.50 CAL	4 IN 1	1.46	1500
25 MM	APDS-T	16.77	300
	HEI-T	20.94	300
	TP-T	11.61	470
40 MM	WSP	20.53	5
	HE-DP	15.72	288
	HE-DP	21.49	50
	TP	12.69	528
60 MM	ILLUM	37.38	40
	SMOKE WP	67.49	18
	HE	55.17	400
81 MM	ILLUM	160.13	55
	HE	90.00	400
	SMOKE WP	123.07	55
120 MM	TP-T	933.36	57
	TPCSDS-T	758.66	123
	HEAT-MP-T	3035.85	8
30 MM	ESTIMATED 21.00 PER ROUND		1000

APPENDIX C

LIFE CYCLE COST (LCC) SUMMARY

The following cost table summarizes all the cost developed in this thesis. All cost are presented in millions of dollars rounded to the nearest thousand.

	CONSTANT COST UNITS			CAR OPTIONS	
	Tank BN	LAR CO	Infantry	LAVS	AAVS
Vehicle Qty	58	27	N/A	231	94
Personnel Cost	25.348	3.439	50.147	13.916	9.75
Vehicle Maint Cost	2.90	0.675	N/A	5.775	3.76
Indiv Equip Upkeep	0.435	0.607	0.855	0.260	0.182
Ammunition Cost	10.701	0.454	1.813	1.382	1.855
Annual Cost	39.384	4.63	52.815	21.334	15.547
20 Yr LCC	786	92	1056	426	310
Cost of 3rd & 4th Ech (over 20 yrs)	2.7	3.3	N/A	28.6	47.2
Cost of SECREPs (over 20 yrs)	61.1	3.0	N/A	25.7	27.7
TOTAL LCC	849.8	98.3	1056	480.3	384.9

TOTAL LCC of a CAR(LAV)	2484.4
TOTAL LCC of a CAR(AAV)	2389.0

APPENDIX D

ESTIMATED FIELDING COST SUMMARY

The following table summarizes the estimated fielding cost presented in this thesis. All values are presented in millions of dollars rounded to the nearest thousand.

		CAR VEHICLE OPTIONS	
	LAR CO	LAV/EQUIP	AAV/EQUIP
Vehicle Procurement	22.542	179.224	9.061
Individual Equipment	0.179	0.794	0.556
Org Equipment	0.945	43.306	30.843
TOTAL FIELDING COST	23.667	223.3	39.9

APPENDIX E

EXAMPLE OF HIGH/LOW CALCULATIONS

To demonstrate the calculations used to develop the High/Low scale the following example is provided. The data set for Drawbar Pull of the mobility criteria is used here as representative of the mobility calculations. First all the values are averaged to develop the standard for this test characteristic. Next the values for each of the vehicles in the sample are averaged to provide each with a comparative score. Then the largest and smallest data points are subtracted to find the sample's range. This range is divided into five groups which correspond to the five rankings used by the High/Low scale. Last, the vehicles are sorted by their test score into the five categories of the scale. The accompanying spreadsheet summarizes these calculations and the final separation by category is provided below. In the Draw bar example the range was calculated to be 49010 measures. When this is divided into the five groups(Low,Below Average,Average,Above Average,High) the increment per group is 9800 measures.

Vehicle	Drawbar Pull	Scale
FIFV	56387	High
AAAV(F)	41613	High
M2A2	37572	Above Average
AAV7A2(F)	36924	Above Average
AAV7A2(S)	33126	Average
AAAV(S)	32771	Average
APC(X)	30887	Average
AAV7A1	30161	Average
M113	16120	Low
LAV 25	7377	Low

Note: None of the test sample vehicles fell into the Below Average group.

Drawbar Spreadsheet

	Hard Surface	Mud	Swamp	Sand	Dry Snow
AAV7A1	35037	31792	32198	26553	25224
AAV7A2(S)	39149	35316	33922	29228	28017
AAV7A2(F)	45250	40497	34151	32390	32335
AAAV(S)	37757	34237	35170	29000	27690
AAAV(F)	49096	43650	42080	37098	36142
APC(X)	35966	32604	32791	27190	25884
M2A2	43791	39287	34223	39287	31272
FIFV	85973	75080	-1799	59996	62686
LAV 25	16756	11856	-3299	3975	7598
M113	19240	17151	18317	13013	12877

SAMPLE AVERAGE	32293.88
RANGE	56387 TO 7377
INCREMENT	9801
SCALE	
HIGH	56386-46585
ABOVE AVERAGE	46584-36783
AVERAGE	36782-26981
BELOW AVERAGE	26980-17179
LOW	17178-7377

VEHICLE AVERAGES	
AAV7A1	30160.8
AAV7A2(S)	33126.4
AAV7A2(F)	36924.6
AAAV(S)	32770.8
AAAV(F)	41613.2
APC(X)	30887
M2A2	37572
FIFV	56387.2
LAV 25	7377.2
M113	16119.6

APPENDIX F

COST VS. CAPABILITY GRAPH

The following graphs are provided to pictorially display the relationship between the CAR options cost and the characteristics measured in this study. The vertical axis are the various vehicle and CAR options listed by cost. The top half of the charts shows the twenty year Life Cycle Cost of the possible CAR options. The bottom half of the charts shows the cost of the individual vehicles and their capabilities. The horizontal axis shows the High/Low Scale. To give the scale added meaning a breakdown by characteristic is provided. Additionally, the location of the icon on the chart also relates to the actual value that icon holds (except on the survivability chart). For example, the AAAV's cost is $2.5 million and the AAAV's Horsepower/Ton icon is all the way to the right of the chart, reflecting its actual value of 31. In the key box the Average/Standard used in this study is listed by characteristic. Firepower is represented by the Stowed Kill calculated from the PK and weapon system evaluation in Chapter V. It is important to note that the CAR(LAV)'s value is the combined total achieved by the 25 mm and .50 caliber weapons. For the AAV a .50 caliber weapon station is used while the value for the 30 mm gun is showed as K*. Survivability is shown on a separate chart because of the large number of plots.

Cost vs. Mobility Characteristics Chart

COST (MILLIONS)	LOW	BELOW AVERAGE	AVERAGE	ABOVE AVERAGE	HIGH
CAR(LAV) 2360	D	H	V		K
CAR(AAV) 2244	H,K		D	V	
AAAV 2.5				V D	K* H
LAV .730	D	H	V		
AAV .O96	H		D	V	

HP/TON	15.2	18.36	21.52	24.68	27.84	31
VCI	61.4	49.12	36.84	24.56	12.28	0
DRAWBAR PULL	7377	17178	26980	36782	46584	56387
KILLS	86	193	301	408	516	624

KEY		AVERAGE/STANDARD
HP/TON	= H	22.7
VCI	= V	33
DRAWBAR PULL	= D	32293
STOWED KILLS	= K	355 (MEDIAN)

NOTE : K* REPRESENTS THE POSSIBLE KILLS THAT A CAR(AAAV) WITH 30MM COULD ACHIEVE

Cost vs. Survivability

COST (MILLIONS)	LOW	BELOW AVERAGE	AVERAGE	ABOVE AVERAGE	HIGH
CAR(LAV) 2360	Y, Z	W	X, 3, 4	1	2
CAR(AAV) 2244	Y, Z		W	X, 3, 4	1, 2
AAAV 2.5	Y, Z		W	X,3, 4	1, 2
LAV .730	Y, Z	W	X, 3, 4	1	2
AAV .O96	Y, Z		W	X, 3, 4	1, 2

KEY

		14.5 MM	30 MM
SHORT RANGE	SINGLE SHOT	= W	1
	5 ROUND BURST	= X	2
LONG RANGE	SINGLE SHOT	= Y	3
	5 ROUND BURST	= Z	4

APPENDIX G

INFLATION INDICES

The follow inflation index values were used to develop the FY 1993 cost used in this study.

	Year	Index
Personnel	90	0.8989
	91	0.9287
	92	0.9650
	93	1.0000
Procurement	90	0.8934
	91	0.9357
	92	0.9683
	93	1.0000
Operation & Maintenance Marine Corps	90	0.8625
	91	0.8994
	92	0.9342
	93	1.0000
Ammunition	90	0.9280
	91	0.9528
	92	0.9770
	93	1.0000

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